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ANNUAL U.S. ARMY HUMAN FACTORS ENGINEERING CONFERENCE (4TH), 9,--ETC(L
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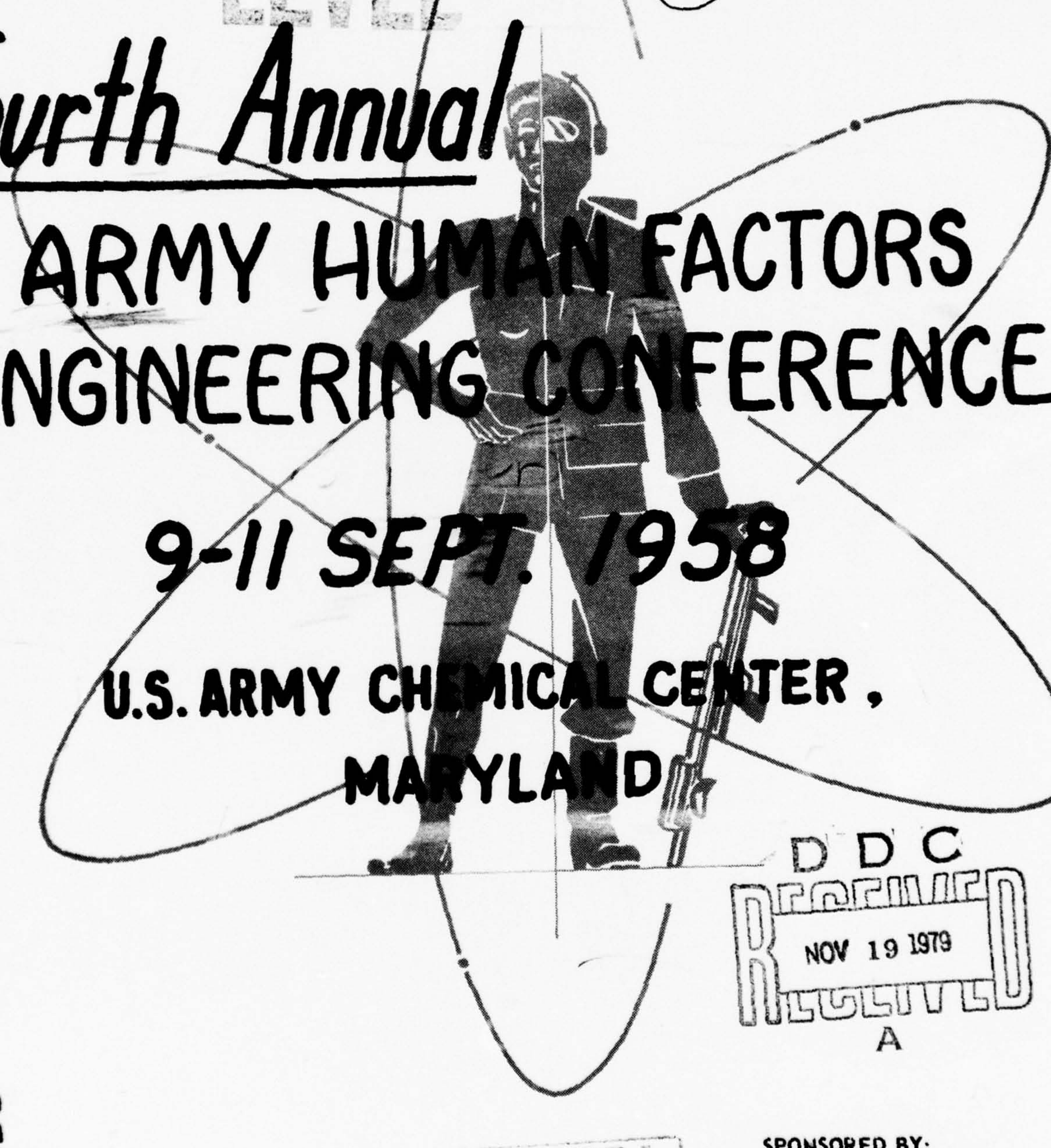

Fourth Annual

ARMY HUMAN FACTORS ENGINEERING CONFERENCE

9-11 SEPT. 1958

U.S. ARMY CHEMICAL CENTER, MARYLAND

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OFFICE OF THE CHIEF OF RESEARCH AND DEVELOPMENT
ARMY RESEARCH OFFICE
WASHINGTON 25, D. C.

CRD/J 31 October 1958

SUBJECT: Fourth Annual U. S. Army Human Factors Engineering Conference

TO: See Distribution

1. This Report is the record of subject Conference held at the Army Chemical Center, Maryland, on 9, 10, and 11 September 1958, and is published and hereby transmitted for the information and retention of the personnel and agencies indicated in the distribution list. The Conference was attended by persons listed in Appendix 1 of this Report, and was sponsored by the Army Research Office of the Office of the Chief of Research and Development, Department of the Army.

2. In sponsoring the fourth of these annual conferences the Army Research Office reaffirms the judgment of the Chief of Research and Development on their value based on the experience of previous years. As stated in my foreword and transmittal of the Third Annual Army Human Factors Engineering Conference Report, that judgment is that these Conferences have demonstrated their value in facilitating interchange of human factors engineering information among the Technical Services and with "user" agencies; and by furnishing, in the Conference Report, a useful and authoritative compendium of the work programs in human factors engineering in all of the Technical Services.

3. Subject Conference has, in all respects, equalled or exceeded its predecessors in promoting these values. This is attributable not only to the excellent facilities and consideration exerted by the Chief Chemical Officer and the Army Chemical Center as hosts, but also to the preliminary planning of the Army's Human Factors Engineering Committee, which has been established by AR 70-5, dated 1 July 1958, as a coordinated Army response to recommendations of preceding conferences.

4. It is anticipated that the Human Factors Engineering Committee will continue its work in preparation for the Fifth Annual U. S. Army Human Factors Engineering Conference in 1959, and will also follow through on opportunities presented in the present and previous Conferences to improve the effectiveness of human factors engineering in Army research and development.

FOR THE CHIEF OF RESEARCH AND DEVELOPMENT:

T. J. Conway

T. J. CONWAY
Brigadier General, GS
Director of Army Research

Distribution:
One copy to each member of the Conference
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(1) Conference Report

FOURTH ANNUAL U. S. ARMY HUMAN FACTORS ENGINEERING CONFERENCE (4th)

(11) Sep 58

9, 10, 11 September 1958

U.S. ARMY CHEMICAL CENTER, MARYLAND

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Conference Report

FOURTH ANNUAL U. S. ARMY HUMAN FACTORS ENGINEERING CONFERENCE

9, 10, 11 September 1958

Army Chemical Center, Maryland

I. INTRODUCTION

1. References:

a. Conference Report, "Army Human Engineering Conference"; The Pentagon, 14-15 December 1955.

b. Report, "Second Annual Army Engineering Psychology Conference"; Army Medical Research Laboratory, Fort Knox, Ky., 7-9 November 1956.

c. Report, "Third Annual Army Human Factors Engineering Conference"; Quartermaster Research & Engineering Command, Natick, Mass., 2-4 October 1957.

d. Army Regulation 70-8, "Research & Development, Human Factors Research," 1 July 1958.

2. Sponsorship and Planning of the Conference.

a. The Annual Army Human Factors Engineering Conference is sponsored by the Chief of Research and Development. Three such Annual Conferences have been previously held, and are reported by references a, b, and c.

b. In accordance with reference d, planning for the Conference, as well as follow-up of its suggestions and recommendations, is accomplished by a Human Factors Engineering Committee. The Committee is composed of representatives of the Chief of Research and Development (Chairman), each of the Army Technical Services, and the U. S. Continental Army Command.

THE ~~3.~~ Purposes of ~~the Conference are~~ THIS REPORT is:

~~a.~~ To provide direct interchange of information on human factors engineering among personnel of Army development agencies, and between these and representatives of user agencies and other qualified individuals.

It also ~~b.~~ ~~To~~ provides recommendations and suggestions to be followed up by the Army Human Factors Engineering Committee ~~(see 2b, above)~~ to assure exploitation of all opportunities for improving man-machine compatibility in the design of Army materiel.

Finally it ~~c.~~ ~~To~~ provides a Conference Report which will serve as a useful and complete single compendium of all Army human factors engineering research and development activities.

4. Presentations and Preparation of Conferees:

a. Appendix 2 of this report was distributed to each conferee in advance of the Conference as "Homework" materials. These materials summarize, for each Army agency having a human factors engineering research and development program:

I Vitae of professional personnel engaged in human factors engineering activities in each agency.

II Current projects of each human factors engineering facility.

III Bibliography of human factors engineering reports published since the previous Conference listing.

b. Presentations, as contained in Chapters III to IX of this Report, were planned by the Human Factors Engineering Committee to be oriented around the central Conference theme, "Army Mobility for Future Warfare."

5. Greetings were addressed to the Conferees by Lt Gen Arthur G. Trudeau, USA, Chief of Research and Development as reproduced on page 3 following.

6. The Conference was called to order in the Post Theater building, Army Chemical Center, Md., at 1030 hours on 9 September 1958 by the General Conference Chairman, Dr. Lynn E. Baker, Army Chief Psychologist.

7. The invocation was pronounced by the Reverend Lawrence H. Jongewaard, Major, U. S. Army, Post Chaplain, Army Chemical Center.

8. Major General Marshall Stubbs, U. S. Army Chief Chemical Officer, welcomed the Conference on behalf of the Chemical Corps as host of the Conference.

9. Brigadier General Harold Walmsley, Commanding General, U. S. Army Chemical Center and Chemical Corps Materiel Command, then expressed the pleasure of his Command in offering its services and facilities for the use of the Conference.

10. Major General John P. Daley, Director of Special Weapons, Office of the Chief of Research and Development, then introduced the keynote speaker, Lieutenant General Edward T. Williams, Deputy Commanding General United States Continental Army Command. The USCONARC presentations, by Lt. Gen. Williams and Col. Ewbank, are contained in Chapter II of this Report.

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF RESEARCH AND DEVELOPMENT
WASHINGTON 25, D. C.

CRD/J

18 August 1958

MEMORANDUM FOR: CONFEREES, FOURTH ANNUAL ARMY HUMAN FACTORS ENGINEERING CONFERENCE

SUBJECT: Greetings to the Conference from OCR&D

1. Since I am unable to be present for this, the fourth of the Army's annual Human Factors Engineering Conferences, I take this means to convey to each of you my desire that you have an interesting and instructive meeting.

2. Your three previous annual conferences have abundantly demonstrated their value to the Army. They have provided a most effective interchange of information among technical services and "user" agencies in design of Army equipment for human use. They have been instrumental in providing a number of recommendations for positive actions to effect improvement in Army research and development of such designs. They have provided a convenient single annual summary of all Army programs bearing on man-machine compatibility.

3. I take this opportunity to remind you that the nature of the Army's mission in war gives unique urgency to the compatibility of the soldier and his weapons. In the Army, the soldier is typically not in a ship which is in battle; he is not in an aircraft which is in battle; he is himself in battle directly, immediately, personally -- a tactical entity of combat power. We must, therefore, exert all efforts to assure that his tools of battle permit him to exploit fully his talents and his tactical opportunities in this situation.

4. For these reasons, as the Chief of Research and Development, I am pleased to sponsor the fourth annual Army Human Factors Engineering Conference and to wish you every success in your work. I join with yours my thanks to the Chemical Corps and the Army Chemical Center for their many courtesies extended as hosts of the Conference.

Arthur G. Trudeau
ARTHUR G. TRUDEAU
Lieutenant General, USA
Chief of Research and Development

II. KEYNOTE ADDRESS

1. "THE NEW MOBILE CONCEPT" [1]

by Lieutenant General Edward T. Williams,
Deputy Commanding General
United States Continental Army Command

[[1] General Williams' address, classified SECRET, cannot profitably be rendered in an unclassified paraphrase. Properly authorized individuals or agencies may obtain a copy of the full text by application to the Army Research Office, ATTN: Human Factors Research Division, The Pentagon, Washington 25, D. C.]

2. "THE APPLICATION OF USER GUIDANCE TO EQUIPMENT DESIGN"

by Colonel K. H. Ewbank, USCONARC

General Williams has described to you the battlefield of the future, emphasizing the need for increased mobility. He has further pointed out some of the specific military requirements for equipment necessary for the successful conduct of modern mobile warfare.

Organizing, training, and equipping an army for this modern battlefield is a tremendous task requiring the combined efforts of our combat leaders, military technicians, and civilian industry. The job of developing and supplying the equipment rests on the Army's technical services and industry. Employing it on the battlefield is the responsibility of the combat forces. The task of insuring that these tools of war which we are developing meet the needs of the soldier demands the best effort from all of us.

Basically, the technical services supply the machines, and the combat forces supply the men. Together they must provide a man-machine combination which will insure that we can achieve victory on the modern mobile battlefield.

For the next few minutes I would like to talk to you about how we must work together to get this winning combination. I will not dwell on past mistakes and errors or point out how the technicians and engineers produced certain gadgets which the soldier couldn't use; or how the soldiers failed properly to utilize the equipment which was given to them. Rather, I will attempt to describe what we should do to prevent such mistakes in the future. Since I am a user representative, I will emphasize the role of the user.

The Commanding General, United States Continental Army Command, has the responsibility for user representation for all battlefield equipment in the Army's Research and Development system. For that reason, during my remarks I will use the terms "USCONARC" and "User" interchangeably.

The United States Continental Army Command has two rather distinct and easily definable missions in the materiel development cycle. First, and prior to actual development, USCONARC states the requirement for an item or system and lists its necessary operational and performance characteristics. And second, after the developer has fabricated the hardware which he thinks will meet the requirement and characteristics, CONARC tests the item or system to determine if it is acceptable and suitable for Army use on the battlefield.

Human factors are primary considerations in the accomplishment of both of these developmental missions. In the preparation of a statement of requirement or of military characteristics, the over-riding consideration is that the equipment must be controlled by, operated by, and maintained by men. And in the conduct of the user test, the objective is to determine the functional suitability of the man-machine combination.

This fitting together of the man and the machine, stated in its simplest terms, shouldn't be a particularly difficult job; the developer should be able to accomplish it without much guidance or interference from the user. The scientists and engineers who design and make the equipment are aware, or certainly should be aware, of man's physical and mental capacities and limitations. They know how much weight a man can lift and carry, how far he can see, and how many dials he can twist or levers he can pull at one time. Great masses of anthropometric data and other such information have been collected and compiled and should be available to the developer and applied to his equipment design. In short, the scientist and

engineer generally are able to provide us with man-machine combinations which fit and function properly under the serene, controlled conditions which prevail in the laboratories and proving grounds.

Unfortunately, that is not enough. Our battles are not fought under the conditions which prevail here at the Army Chemical Center or at other such proving grounds. Battles are fought amid conditions of almost indescribable confusion and in locales having the widest extremes of weather, climate, and terrain. And battlefield equipment is operated and maintained by men who are under the most extreme mental and physical stress. These facts greatly complicate the problem. It is these facts which give a major role to the military user in the design phase of development, and dominate the conduct of the final user tests.

If the user states his requirement and prepares his military characteristics and then sits back and waits for the equipment to be handed to him for user test, he hasn't done his job. The user test, if properly conducted, will reveal any deficiencies which might exist in the man-machine combination. But that is too late. Correction of such deficiencies at that stage of development is costly and time consuming. Expensive modifications and engineering design changes must be made. And retesting, in such instances, is almost always required. The user must "get into the act" earlier and stay in it throughout the entire process of development.

The user must keep the developer aware of these complex battlefield conditions at all stages of development. He must let the design engineer, working on his original drawings, know with as much accuracy as possible just how, where, when and by whom the item is to be used. And he must continue to provide such information throughout all of the other developmental stages, including the construction of mock-ups and prototypes and the conduct of technical and engineering tests. In this manner, with everyone engaged in the development of an item kept aware of the desires of the ultimate user, it will be possible to eliminate many design errors and other required changes in the late stages of the development cycle.

Of course, all this will not eliminate the need for final service test wherein the equipment is married-up with soldiers under simulated battlefield conditions. Service tests will continue to reveal deficiencies and need for design modification. During Fiscal Year 1958, 22% of the items tested were found to be unsatisfactory for combat use. We hope to reach the time when only minor, easily corrected deficiencies are found during user service tests. Closer cooperation between the user and the developer throughout development should eliminate a great many of the more easily recognized design errors which frequently creep into our military equipment, and the earlier we recognize and correct such errors, the more time and money we will save. And both time and money are in short supply now and can be expected to be even scarcer in the future.

I believe we can all agree that the user must keep the developer constantly aware of the contemplated use of the equipment. But we are still faced with a very serious and complicated problem of how to do this. It has already been said that battlefields present a vastly complex condition with wide variations of terrain and environment. And because of this complexity, it is extremely difficult to visualize just what the conditions on future battlefields will be. It is even more difficult to describe this visualization to the engineer in understandable and practical terms which can be applied to equipment design.

It is difficult to find well qualified personnel to represent the user properly in giving guidance during the development of items. Thanks to the cooperation of Department of Army personnel assignment agencies we have been able to retain many of our good men--both officer and enlisted--in the materiel development field. For example, our executive officer in the materiel developments section, USCONARC has had two tours with the Arctic Test Board--the last one as President--and between those tours spent slightly more than a year in the Materiel Developments Section, USCONARC. Many enlisted men get repetitive tours with boards and several key civilian employees have been with the boards for many years. This gives us much-needed continuity. We also usually are given a choice of several for our key jobs so that we can select the best qualified. Generally we feel that we have been very fortunate in being able to get and keep good people in the materiel developments field. We also find that short school courses, symposia, and conferences such as this are very valuable in improving the education and background of our people.

Applying effective user guidance to our developmental effort is a very important matter which will require a great deal of cooperation and effort on the part of everyone concerned - both developers and users. Users must supply well thought-out, coordinated guidance which is based upon known battlefield practice and conditions but geared to future organizations and concepts. And developers must be so receptive to such guidance that they are readily willing to apply it to the job they are doing.

For the most part, the developers are not only receptive to user guidance but they actively seek it. Engineers and technicians representing our technical services and industry seldom miss an opportunity to ask

a combat soldier what he thinks of all items of equipment which they have under development. And the soldier never fails to respond to such an opportunity to speak his piece. But such guidance, given on the spur of the moment, without careful study, is dangerous. Almost always, the opinion expressed is based entirely upon the adviser's personal combat experience. If he fought in the jungle, his views will be colored by jungle warfare considerations. If his experience has been in the far north, he may be unduly concerned with how the item will work at below-zero temperatures while operated by a soldier wearing arctic mittens. Seldom if ever will such off-hand opinions represent a broad background of experience coupled with a thorough understanding of future concepts. Therefore, design modifications based upon such "off the cuff" user guidance is useless and wasteful.

The point I have been trying to get over is this. Early knowledge of intended battlefield use is essential for the developer. Battlefield conditions are so complex and variable that they are difficult to describe. No one individual, regardless of his experience and professional military competence, can provide complete user guidance after cursory examination of a design or mock-up or in reply to off-hand questions.

I believe that these facts are responsible for a great deal of user-developer conflict. The user is dissatisfied because his wishes are not reflected in the developer's product. And the developer is frustrated by his inability to find out precisely what the user wants. And there is every prospect of this situation becoming increasingly worse. The modern, mobile battlefield, described to you by General Williams, is far more complex than the one we experienced during World War II and in Korea. And tactical organizations and concepts are constantly changing with the introduction of new weapons systems.

Now that I have stated what I believe to be a rather serious problem, I will propose some measures to be taken which will constitute a long step in the right direction even though they may not be a complete solution.

First, USCONARC must anticipate the problems the designer will encounter and must be prepared to furnish him with detailed user guidance, thoroughly staffed and coordinated through combat development agencies, USCONARC boards, service schools, etc., in the same manner as is presently done with military characteristics. USCONARC must insure that recommendations are considered carefully by those agencies that are qualified to give sound answers to the developer. This of course is a USCONARC job.

Secondly, the developer must call upon the user for specific guidance and evaluation at specific stages of development such as completion of engineering design, fabrication of mock-ups, and production of prototypes. However, off-hand answers should not be sought at these points in the development cycle. Rather, specific questions should be asked and specific designs offered for scrutiny with sufficient time allowed for thorough user coordination of replies. If a conference is called for such a purpose, furnish a detailed agenda far enough ahead of time to enable the conferees to speak with authority. Don't couple a complex question with a demand to "speak now or forever hold your peace." The proper answers just don't come that easily.

You in your work in human factors engineering can assist the user by seeking his advise. We have many men, who through their background of practical experience, can help in the design of equipment. Often the sergeant who works with equipment daily sees things that you and I don't. For example, recently a sergeant looked at a mock-up of a weapon and said that the latch wouldn't raise in the space available. He was right and the design engineers were wrong.

I spent last week at the Army Ordnance Missile Command reviewing the design of a new missile. The meeting was most profitable from the point of view of both the developer and the user. I believe that the three day meeting will save a considerable amount of both time and money - two very important commodities.

I have been using the term "user guidance" in a rather general sense, but in reaility I have not been going very far afield from the specific theme of this conference. User considerations in the development of military hardware are almost entirely human factors considerations. When we develop a new piece of equipment, the user is concerned with how many men will be required to use it, how much training the crew will require, how difficult it will be for men to maintain it, how easily men can transport it, how quickly men can put it in action or take it out of action, and how effectively men can employ it. For instance, we are not much concerned with the ballistic accuracy of a weapon fired from a bench rest under controlled conditions. But we are vitally concerned with how accurately a man can fire it under the variable conditions of the battlefield. We seldom care how fast a vehicle will go, but we do care how fast a man can drive it on the battlefield.

Increased firepower of weapons and other technological advancements will undoubtedly reduce the density of men on the battlefield to reduce vulnerability. But we will never remove the need for men to secure key

points on the ground; and as the effectiveness and complexity of our equipments increases, our reliance on the ability of a man to employ them also increases. The human factor from the user standpoint remains a most important factor. In short, what I have said about applying user guidance to the design of military equipment is primarily concerned with applying the human factors to the equipment design. That, of course, is a mission of the technical services as the developer.

In summary, I believe that the user and developer--that is, the field soldier and the technician--must work together continuously and closely throughout the development cycle of all military equipment.

Such cooperation, particularly in the early design stages of development, will eliminate many costly and time consuming errors.

The user must anticipate and problems confronting the developer and be prepared to furnish him with timely advice and guidance as to the contemplated use of the equipment under development.

The developer must be responsive to the requirements of the user and be kept fully aware of changing considerations and concepts.

And if these things are done, the combat forces and the technical services, working together, will be able to produce a man-machine combination which will assure victory on any battlefield.

3. ANIP FILM PRESENTATION

[As appropriately complementary to the above USCONARC presentations a film report of the Army-Navy Instrumentation Program (ANIP) was presented by the U. S. Army Signal Corps. The film described the development and possible applications of the concept of a "terrain analogue" for the presentation of information to operators and pilots of future military vehicles. Dr. William E. Federson, of Bell Helicopter Corporation, was introduced to the Conference by the Chairman as representing, and available to answer questions on, that Corporation's over-all monitoring responsibility for the ANIP project.]

III. U.S. CHEMICAL CORPS PRESENTATION

by Lieutenant Colonel William G. Willman, CmlC
Assistant to Deputy Chief Chemical Officer for
Scientific Activities

The papers presented by USCONARC at this Conference make it clear that increased battlefield mobility will provide a means of successfully conducting a limited war and thus minimize the opportunity of having a limited conflict expand into an all-out war. It should be noted, however, that in the attempt to design modern weapons systems with increased mobility, it is most likely that the complexity of the equipment will be increased. Any increase in complexity creates severe operational and maintenance problems for the personnel who are required to use these weapons systems effectively.

There are at least two ways in which this problem could be solved. First, more emphasis can be placed on the selection of the personnel who will operate and maintain the equipment and materials which make up the weapons systems. The standards for personnel selection can be raised, with a corresponding increase in the amount and quality of the training these selected personnel are subjected to. The second solution would be to simplify the equipment or incorporate the maximum degree of human factors engineering into the weapons systems so that less highly selected personnel with a minimum of training would be capable of operating them effectively.

To decide on which procedure to follow is not easy. Probably a middle road should be followed and we should do both, but since selection and training of equipment operators are not the primary considerations of this Conference, they will, for this reason only, be considered as having a secondary role.

At the expense of appearing contradictory, it is admitted that education and training is an important tool in developing a greater appreciation and use of human factors engineering in the conduct of research and development programs. The Chemical Corps uses the project engineer system in administering its research and development program. Briefly, this system consists of establishing a group comprised of a development engineer, a production engineer, and an industrial engineer as a steering committee for each end item being developed. As the development progresses through prototype engineering test, product engineering, and final mass production phases, leadership of the group passes to the member primarily concerned with that particular phase.

Last winter the Chemical Corps decided to conduct an experimental series of seminars to indoctrinate these project engineers in the fundamental principles of human factors engineering. These seminars were monitored by human factors engineers from industry and educational institutions and were intended to develop appreciation of human factors engineering. It is difficult to assess all of the benefits of this course, but there has been a definite awakening and awareness of the problems and there has been some feedback in the form of suggestions for research projects that would provide data beneficial to the design engineers. Details of this seminar series will undoubtedly be covered elsewhere in this Conference.

Battlefield mobility necessitates consideration of simplicity of items, multipurpose items, compactness, and capability to operate in a wide range of environments. Items must be lightweight, constructed and packed for rough handling, easily assembled, readily maintained and repacked for reshipment.

The Chemical Corps has been considering these factors in the design of new items for use in mobile warfare. Some of them will be enumerated here for the dual purpose of informing the conferees of the items in development, as well as some of the human factors engineering problems involved in their development. Design problems are considerably aggravated by environmental changes. Many problems in design were solved so that the equipment was adequate for temperate zone operations and maintenance. These same items when tested under tropical or arctic conditions were found to be unsuitable for use due to the limitations and restrictions on human capabilities in those environments.

Arctic and tropical environments often result in an aggravated effect of temperature on both the equipment and the operators. For example, exposure to severe cold may evoke a profound autonomic reaction on the individual operator and in addition adversely affect the operation of the equipment which he must operate. (e.g.: E13 Mask.)

PRESENT DEVELOPMENTS

In the field of radiological detection, the Chemical Corps is developing a Tactical Dosimeter, E5, to measure the amount of radiation to which a person may have been exposed. It is easily read requiring no measuring equipment, can be carried by each soldier and will be particularly useful to troop units in rapidly moving situations. [FILM]

To assure positive identification of the more toxic agents in the least possible time, the Chemical Corps is developing an expendable G and V agent detecter. The expendable agent detecter will operate on a color-change principle, and will immediately indicate the presence of G and V agents. The expendable agent detecter will provide the soldier in the field with an extremely small, lightweight detection device, which will furnish timely warning against G and V agent attack during the day or night. The detection device will be in the nature of a small patch, not over 0.5 ounces in weight, and will be displayed on the individual soldier or on the equipment so that it will be readily visible to the wearing individual and others in the immediate vicinity. It is contemplated that the device will be available to troops on the same basis as the protective mask.

Since the G-agents give little or no sensory warning of their presence which could warn personnel to mask, the Chemical Corps is developing a minaturized Automatic Field Alarm, E41. The alarm will operate continuously for 24 hours and is capable of operating while being carried by an individual. The minaturized alarm is being developed to replace the Alarm, Field Automatic, #21 which is relatively large and heavy, weighing approximately 100 pounds including the weight of the batteries. [FILM]

Successful use of the portable flame thrower M2A1 in World War II established the importance of the weapon in the arming of combat troops. However, experience indicated the need for a new, lightweight, portable weapon. During the Korean conflict battlefield experience reemphasized the need for a lightweight portable flame thrower that would replace in part or supplement the requirement for the standard M2A1 model. To meet this requirement the Chemical Corps developed and standardized Flame Thrower, Portable, One-Shot, M8. The M8 Flame Thrower provides the user in the field with a lightweight weapon that can be easily carried, operated and quickly disposed of by one man. [FILM]

Further investigation conducted in the flame thrower field resulted in the development of a multishot replacement (Portable Flame Thrower Group Assembly E32R1 with M7 Gun) for the M2A1 Flame Thrower with a reduction in weight and silhouette. The weight of the flame thrower was reduced from 74.5 pounds to 49.5 pounds; and in addition, the length of the gun was changed from 30 inches to 21 inches. Human engineering tests conducted showed that valve grip and trigger positioning of the M7 Gun is superior, in terms of ease of operation, to the positioning of the corresponding components of the M2A1 Gun. Design of the M7 Gun is such that the ignition lever and ignition safety lever can be operated with ease in the Arctic with the operator wearing gloves. [FILM]

The Chemical Corps, in harmony with the theme of battlefield mobility and flexibility, has developed a mechanized flame thrower in kit form for AUV/APC class vehicles. The Flame Thrower Kit, E31-36, is specifically designed for installation in an M59 armored infantry vehicle; but may be installed in other types of vehicles having a comparable space and facilities. Formerly, obsolescence of the vehicle usually resulted in obsolescence or modification of the flame thrower. Installation of the kit on a vehicle requires four men - 4-1/2 hours. [FILM]

In the field of munitions, human factors engineering is also involved. A typical example of this is illustrated by the E5 Chemical Land Mine. This mine must be readily distinguished from the standard HE Ordnance mine when planted in the ground. Human factors engineering resulted in a design which provided for small projections on the top surface of the mine. These projections permit easy identification through tactual application of the fingers over the mine. Another feature is the carrying handle which was designed to permit a soldier to carry the mine with one hand. To incorporate this feature, it was necessary that the handle be completely recessed within the outer periphery of the mine so that it would not interfere with mechanical planting. [FILM]

Continuing in the munitions field, the Chemical Corps has several rockets involving human engineering. Typical of these are the T238 Gas Rocket and the E42 Incendiary Rocket. The T238 Rocket is a ground-to-ground rocket system for use against area targets for optimum dissemination of chemical agents. The rocket was designed so that all components of the rocket system, including the launcher, are man portable. The filled rocket is about 75 inches long and weighs 66 pounds. The launcher is adaptable for use either on the ground or from the bed of a truck. [FILM]

The E42R1 Incendiary Rocket is a ground-to-ground rocket system for use against incendiary targets and camouflaged areas. The incendiary rocket expands in range and use the standard flame thrower weapon systems. The entire system is approximately 70 inches long, 8-5/8 inches in diameter, and weighs about 68 pounds. The incendiary rocket including launcher is easily trans-

portable, and can be readily assembled in the field. One of its features includes economy in manufacture. [FILM]

For concealment of paratroop jumps and other combat operations, the Chemical Corps is developing a new type of smoke screen. The new method involves a smoke spray tank carried in an airplane, producing a cloud free of the gaps common to other smoke screens. [FILM]

LONG RANGE PLANS

We have just reviewed some typical items in the current research and development program and have noted human engineering problems related to each item. Before closing we might take a brief look at the Chemical Corps's long range program with particular emphasis on the specific areas which will have an impact on the mobility of the Army of the future.

First we should consider the subject of protection of the individual soldier as well as the small combat unit against chemical, biological, and radiological attack. Our research program is oriented toward developing a small, expendable, lightweight protective mask for the individual soldier which will have essentially the same protection as that of the present heavy, cumbersome, breathing-resistant, conventional mask. The individual soldier will wear environmental clothing which will protect against all toxic battlefield hazards. Each individual will be equipped with detection and alarm devices which will be smaller, simpler, and more easily manipulated than those currently in development. There will be required simple, lightweight collective protectors adaptable to vans, rooms, dugouts, and the like, which will provide cases for troops operating in toxic atmospheres. Here they may get relief by removal of masks for eating, smoking, and personal comfort. Impending biological and chemical attacks on small isolated units will be detected by scanning devices which will involve infrared units. These devices will be follow up developments of our present chemical infrared detector. [FILM]

Finally I would like to tell you about how the Chemical Corps proposes to provide chemical and biological agents in the highly mobile warfare of the future when fixed installations, manufacturing plants, and depots will be highly vulnerable to enemy attack. We are exploring the possibility of manufacturing and filling facilities in mobile units which could be dispersed and provide difficult targets for the enemy to locate. In addition they could be moved close to the point of use thus minimizing the logistic problems involved in transporting toxic agents normally manufactured in Zone of Interior facilities. [FILM]

In conclusion, every effort is being made to orient the research program to the type of warfare and the type of Army organization which will be on the battlefield beyond 10 years from now. Such an Army will undoubtedly depend on mobility for its continued existence, since the enemy will have the means to annihilate any collection of troops which it is capable of observing and zeroing in. This obviously requires unconventional thinking in determining the type of equipment and weapons systems that will be needed in such an era. I want to stress again the urgency we see in having sound research towards carefully defined objectives, coupled with a system by which breakthroughs in research can rapidly be exploited through development of hardware. The many things that are necessary in development, including thorough and complete human engineering, must be done at the earliest possible point in the development program. We must find means by which our human engineers can assist in expediting development and the provision of superior materiel to the using services.

IV. U.S. ARMY MEDICAL SERVICE PRESENTATIONS

1. "DECREMENTS IN DRIVING SKILL AS A FUNCTION OF CUMULATIVE ENVIRONMENTAL STRESSES"

by
Marvin J. Herbert
USAMRL, Ft. Knox, Ky.

The keynote of this conference is mobility in modern warfare. The old maxim of getting to the objective "firstest with the mostest" now takes on a "new look" with emphasis on "firstest!"

A look at today's armament is sufficient to convince us that speed and maneuverability are prime engineering objectives. We see our tracked and wheeled vehicles supplied with greater power and adapted to a greater variety of terrains - some not limited to land activity alone, but adapted to water or air travel as well. It requires no great imagination to foresee the day when special vehicles will be equally "at home" on the land, in the air, and on the water.

Yet, more impressive is the progress of the engineers in the design of flying equipment to give us greater flexibility, speed, and mobility in the positioning of military materials and personnel. In World War II the cargo plane and the paratrooper teamed up to produce the newest thing in a fluid and quick-striking attack force. In Korea the helicopter came into its own as a versatile instrument for supply, reconnaissance, and personnel evacuation. Today the helicopter appears in many forms ranging from the giant cargo and personnel carriers to the one-man 'copter and the flying platform, enabling us to add offense as another facet of its versatility. In the war of tomorrow, each fighting man will be a miniature army possessing his own nuclear weapons and a means of transportation which will allow him to circumvent most land and water barriers. He will be extremely dependent on radio communication, for the command of which he as a part will be greatly dispersed, by present standards, and will flow in and out of a line of battle covering hundreds of miles.

Since he and his unit will be in a constant state of flux, it will be necessary to set up large numbers of small mobile supply bases which will be shuttled around to conform to ever-changing "front" lines, yet remain ready to supply the needs of men and machines.

The present and growing emphasis on the importance of speed and flexibility in equipment and the greater responsibility, stamina, and skill required of fighting men in modern warfare forces the engineering psychologist to question his progress in preparing the man for the machine.

We sometimes overlook the fact that in most instances the capabilities of the machine may be vitiated or negated by the ineffectiveness of the operator. Thus, in reference to mobility, we are forced to recognize that our equipment is geared to a more or less effective human operator. Any factor that contributes to poorer human performance, reduces mobility.

One of the principal agents in the impairment of human performance is the breakdown of motor skills under the influence of continuing environmental stresses. The more intricate the skill the fewer stressors and the shorter the stress period necessary to produce performance decrement. At Fort Knox we have begun an extensive research program on complex psychomotor functions. Our initial efforts are being directed to the problems of skill-fatigue in vehicle driving and the identification of basic skills underlying the driving task.

Traditionally, the condition of performance deterioration as a function of long exposure to environmental stresses has been viewed as fatigue of the physiological type found in hard physical labor. So-called "sensory deficits" associated with long exposure to physical stimuli are also frequently explained on purely physiological grounds. It is disturbing to recognize these tendencies when one considers the fact that in neither of the two most widely cited "driver fatigue" studies reported in this country were they able to demonstrate the physiological changes predicted.

Our research orientation will indicate that though we recognize physiological breakdown to be of primary importance in the explanation of fatigue following hard labor, we believe that in the case of the more complex psychomotor skills, performance decrement will be essentially due to several psychological factors.

Bartlett's views on the problem are in accordance with some of our beliefs. He states, "One must distinguish between the

type of fatigue produced by protracted hard physical effort and that which calls for little continuous muscular reaction but demands persistent concentration and a high degree of skill. Complex, coordinated, and accurately-timed activities, rather than simple repetitive movement must fit in with one another, each being accurately timed to begin and finish without interference by others. One essential feature is that although the desired skill can be performed, it is not carried out correctly unless particular care is taken."

He later said: "The individual responds to a constantly changing environment, which cannot be defined in terms of its separate elements. The various stimuli form a pattern, within which their arrangement and value may change without interfering with the general situation. A skilled operator responds to coordinated stimuli and learns to set up standards or limits within which each separate stimulus may vary without requiring a response. Since there is a meaningful relationship among all stimuli, any response is conditioned by simultaneous indications from all of them. In 'skill fatigue' the standards accepted and followed by the central nervous system unwittingly deteriorate. While one thinks that performance is improving, it becomes progressively poorer. At first it is more likely that the right actions will be performed at the wrong time than that the wrong ones will be made. But if accurate timing is insisted upon, gross mistakes may appear, the stimulus field splits up, and the characteristics of its pattern alter. It becomes a collection of unconnected signals for action, with some predominating over others. Those stimuli which are in the margin of the pattern and not too closely organized with the central field are ignored or forgotten, and important responses may be omitted."

Our observations of driver behavior on tests designed to reflect skill decrement convince me that Bartlett's analysis is correct as far as it goes. One must now ask the question, "What is the mechanism that forces the skilled performer to commit errors, tolerate greater error, and lose his timing?"

A possible answer to this question occurred to me when it became evidence that many "tired" drivers performed more like "learners" than as skilled personnel.

I would like to propose that the mechanism operating in skill decrement is that of regression. Due to an alteration in the stimulus patterns, the operator unwittingly is forced to employ more primative, less skilled responses, more nearly (but not exactly) like those of the learner.

I suggest that the acquisition of a motor skill is complete when the performer reaches the stage of practice where he no longer is in conflict as to which pattern of stimuli--the internal or external--he must attend primarily if not exclusively. Until he can execute the necessary coordinated movements without particular attention to the acts *themselves*, *his performance* will not be skilled. When he does reach this level, his attention can be pretty fully directed to the external stimulus patterns.

Skill decrement will appear whenever an event revivifies the learner conflict through the processes of increasing the number or strength of internal stimuli, or decreasing the number or strength of external stimuli. When either of these occurs the internal stimulus pattern naturally commands the performer's *attention guaranteeing a further* reduction in the perception of external stimuli, and creating the necessary antecedents for the appearance of the primitive and unskilled response systems which were always associated with the attention to internal stimuli.

Just as we share Bartlett's views on "skill fatigue" so too do we agree with him when he states the great need for instruments which are sensitive to it.

In 1950, Welford, Brown, and Gabb proposed a set of principles to be followed in designing tests sensitive to "skill fatigue" as Sir Frederick defined it. They stipulated that: (a) the operator must be given a task set in a pattern of serial performance involving a sequence of interrelated moves both mental and bodily; (b) the performance must involve continued exercise, the limits of continuation being determined empirically; (c) in the most significant cases it appears *that the starting signals of the performance* have some element of ambiguity which becomes progressively less and less as performance continues. That is to say, the operator can begin in more than one of a known number of ways, but as he moves to the completing stage of any cycle of manipulation the "open" possibilities become fewer and eventually only one-way manipulation is possible. (d) scoring must yield some measure of over-all performance but also some measures of the incidence and especially the timing of contributory items of performance. The criteria will have to do with the relation of over-all measures to the number and timing of internal items or moves of manipulation. Whatever the form such measures may take in particular cases, fatigue will always be indicated by some reduction in the internal economy of performance relative to the final level of achievement."

We have attempted to follow these principles in designing a number of driving situation tests in the field. These have had a preliminary run at the Yuma Desert Test Station and are now under construction at Fort Knox to be ready for use in September.

Our initial work at Yuma consisted of the design and construction of tests which would

be sensitive enough to detect differences in vehicle manipulation of subjects exposed to varying hours of cross-country driving. Employing "hours-of-driving" as the criterion, the several test measures were validated and their reliabilities determined. For the individual measures, validity coefficients ranged from .18 to .38. Reliability ranged from .35 to .88. A composite score based on four of the fifteen measures employed yielded a validity coefficient of .42 and a reliability coefficient of .96. A factor analysis was employed in an effort to identify basic elements underlying driving skill. Seven factors have been tentatively named: spatial judgment, foot coordination, parallel parking, two varieties of backing, tracking, and gross adjustment.

Our research program proceeds along four interdependent paths:

1. The identification of basic factors in various motor skills, and a search for factors common to all.

2. Design of test instruments which will be sensitive to variations in motor skill patterns.

3. Measurement of the stressfulness of several environmental factors.

4. Search for techniques and devices to reduce or delay the onset of skill decrement.

2. "VESTIBULAR FUNCTIONS IN ANGULAR ACCELERATION"

by

Dr. Fred E. Guedry, Jr.
USAMRL, Ft. Knox, Ky.

A highly mobile military unit will necessarily involve means of transporting personnel and equipment rapidly from one area to another. Such means of transportation may involve more than usual exposure to linear and angular acceleration which in a few individuals produces complete incapacitation, in some individuals vomiting, in others feelings of nausea and tiredness, and in still others little or no apparent effects.

There are a number of things which can be done about such problems. First, individuals who are abnormally disturbed by angular and linear accelerations can be selected in advance and eliminated. Second, drugs and training can be administered to alleviate some of the symptoms. Third, certain kinds of situations which are particularly troublesome can be avoided.

All of these preventive measures, if they are to be maximally effective, demand knowledge of the physiological mechanisms involved during unusual exposure to linear and angular accelerations.

The vestibular system is a very sensitive detector of linear and angular accelerations. It is a system of sense organs uniquely adapted to initiate sensory information and compensatory reactions in response to angular and linear accelerations of the head.

Recently the vestibular system has received added attention because of anticipated problems in manned earth satellites and space travel. This somewhat unusual means of transportation is expected to produce either weightlessness or continuous rotation, either one of which will constitute a very unusual stimulus situation for the vestibular system.

The vestibular end-organs are located in the temporal bone. They are the non-auditory sense organs of the inner-ear.

Each inner ear contains three semicircular canals and a utricle. The canals contain sensory endings which detect angular accelerations. The utricle contains sensory endings which detect linear accelerations.

The canals contain a fluid called endolymph and each canal has a swelling at one end called the ampulla. Within the ampulla is a gelatinous-like projection called the cupula. A considerable amount of research has indicated that the cupula-endolymph system responds to angular acceleration like an over-critically damped torsion pendulum, with the elasticity of the cupula supplying the restoring couple. Furthermore, it is fairly well established that the set of canals which lie most nearly in the plane of rotation are the canals which are maximally stimulated.

With these considerations in mind, let us consider what happens when a person simply tips his head while riding in some vehicle which is turning, particularly a vehicle which is turning at a constant rate. If we assume that the individual is sitting upright and rotating toward his right shoulder at a constant rate, when he tips his head toward his left shoulder, he will feel as though he is tumbling forward. However, his experience is confusing because his experienced rate of tumble somehow seems to be incompatible with the experienced angular displacement from vertical.

The point to be made here is that the vestibular system has been stimulated in a very unusual manner; i.e., the so-called "Coriolis" accelerations. When the person tips his head toward his left shoulder he brings the vertical canals into the plane of rotation. This approximates a situation in the canals which would normally be produced only by a rapid forward tumble through a considerable angle. However, the direction and rate of displacement of the otoliths does

not correspond with that which would be produced by the direction and rate of tumble which is signalled by the canals. In other words, if a person had actually tumbled forward, the canal system and the utricular system would have given coordinated information regarding angular displacement of the body axis from gravity, i.e., the direction of the angular displacement signalled by the otoliths and the direction of the angular velocity signalled by the canals would have been the same. However, in the abnormal situation described, these two sources of sensory input within a single system of sense organs provide conflicting information and trigger incompatible compensatory reactions, none of which are appropriate to the forces acting on the body. It is interesting to note that tipping the head in certain ways with respect to the axis of rotation of a turntable rotating at a constant rate is one of the most effective means of producing motion sickness.

Another means of producing disorientation and sickness involves a conflict in information between the visual and vestibular systems. For example, if the vestibular system is stimulated in a fashion to produce a sensation of bodily rotation simultaneously with visual stimulation indicating that the body is stationary, motion sickness and complaints of nausea are more common than in the same vestibular situation without the conflicting visual stimulation. An especially interesting example of conflicting sensory information apparently leading to embarrassment for the human operator is provided by an experimental flight stimulator. Operators were provided with controls which manipulated a very realistic visual environment such that relative movement between the visual world and the pilot would simulate the maneuvers of an aircraft. In this situation visual information indicated motion, whereas vestibular information indicated no movement. Operators apparently were more disturbed by the simulated maneuvers than by the same maneuvers in the aircraft.

Situations similar to those mentioned probably occur occasionally in a mild form in most means of land transportation; more often and in more severe form in conventional aircraft and in ships at sea; and will probably occur in a severe form in most men in a rotating satellite if the rate of rotation exceeds some as yet undetermined minimum, probably between 5 and 15 rpm.

Part of our current program of vestibular research at USAMRL is devoted specifically to the study of the phenomena which occur when a person moves his head with respect to axis of rotation of a turntable. The angular velocity of the turntable, the angular acceleration which initiates the rotation and the deceleration which stops it, the time elapsed between the angular acceleration and the head movement, the direction, total displacement, and velocity of the head movement, the distance of the head from the center of rotation, the orientation of the body with respect to the axis of rotation and the kind of visual orientation to the environment are all relevant variables in determining the direction and intensity of the experiential phenomena and compensatory reactions. These variables are currently under investigation in our laboratory at USAMRL.

Most of the completed vestibular research in our laboratory has dealt with the theoretical control of vestibular reactions by the vestibular end-organ. Most of these experiments have dealt with relations between subjective phenomena and angular acceleration and how well these relations, in turn, are predicted by current theory of the cupula-endolymph system.

As I mentoned earlier, a considerable amount of research has indicated that the cupula responds to angular acceleration like an overcritically damped torsion pendulum. This means that the behavior of the cupula is predictable once estimates have been made for the mass, viscosity, and elasticity of the cupula-endolymph system. Such estimates have been made by several investigators and henceforth when I refer to theoretical predictions, I will be referring to theoretical predictions based upon the estimates made by a group of workers in Holland including van Egmond and Groen (2).

Based principally upon Lowenstein's work (9), it appears that the cupula of the two ears operate in pairs somewhat like the double-ended input of a push-pull electronic amplifier. This is illustrated in figure 1, which indicates that when the head is accelerated, the rate of firing is stepped up in one ear while in the other, the rate is diminished below the spontaneous resting rate. Lowenstein's results have indicated further that the rate of discharge of the peripheral vestibular nerve is directly related to the theoretical displacement of the cupula from its resting position. Going one step further, it has been theorized that the magnitude and direction of the subjective reaction and the ocular compensatory reaction are also directly related to the theoretical cupula deflection.

A number of experiments have been conducted in our laboratory to test the predictions of this theory. The apparatus used in these experiments consisted of a large turntable, nine feet in diameter, arranged in these experiments so that the subject's head was located at the center of rotation and tilted slightly forward to place the plane of the lateral canals approximately in the plane of rotation.

The subject's experience under these circumstances is not disturbing as long as he does not move his head with respect to

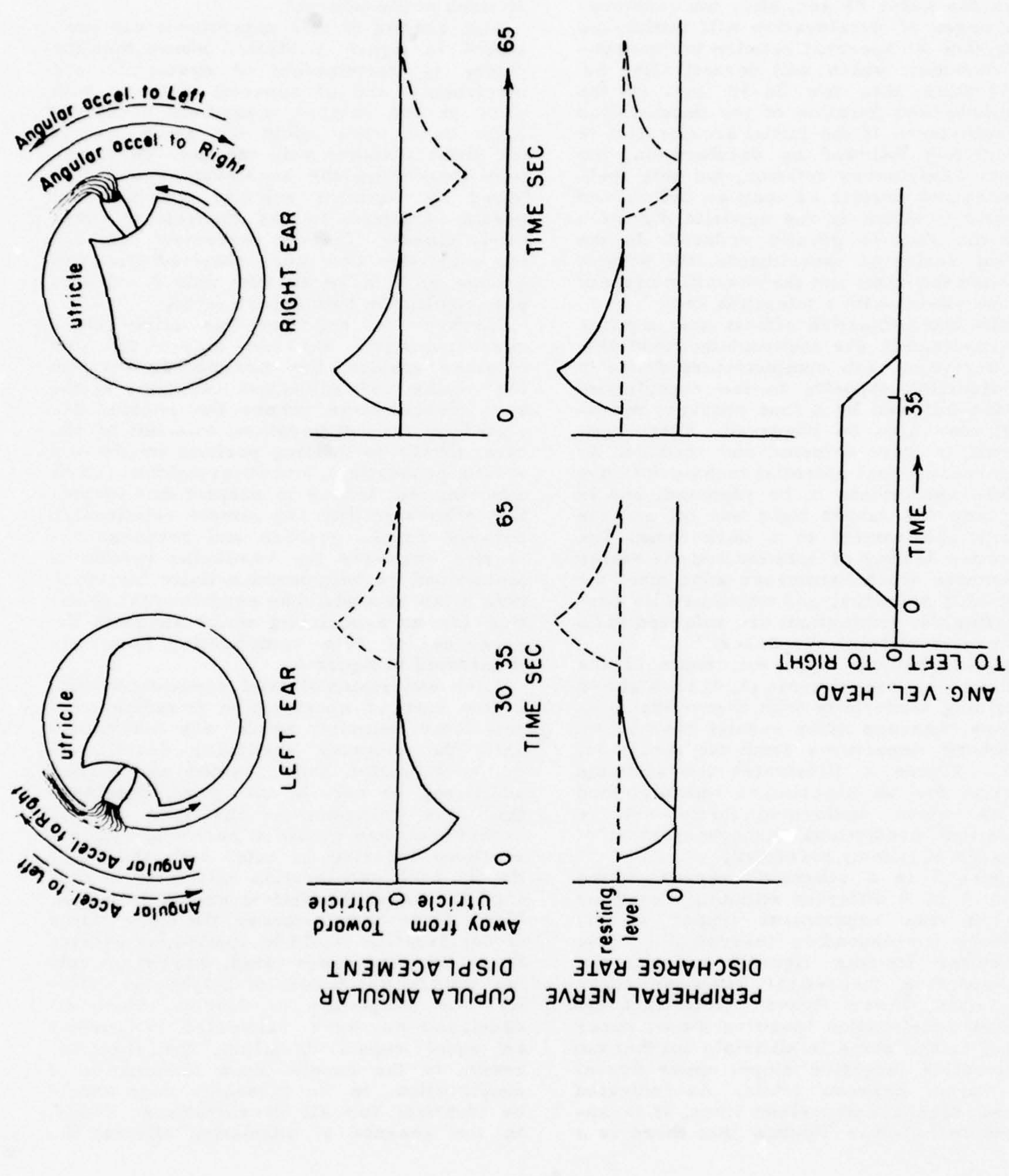

Figure 1. --Comparisons of the angular displacements of right and left cupolas, and their associated peripheral nerve discharge rates, during rotation of the head.

the axis of rotation. If for example he is rotated in a clockwise direction in a dark room while looking at a faint target which rotates with him, he will simply feel that he is rotating in a clockwise direction, i.e., making a right turn. This feeling of rotation will commence shortly after he starts rotating and will continue about 20-30 sec (if the magnitude and duration of the acceleration are sufficient) after a constant velocity is attained. If a constant velocity is maintained for about 25 sec. after the acceleration, onset of deceleration will initiate an experience of apparent rotation in the opposite direction which will persist after the deceleration also for 20-30 sec. (if the magnitude and duration of the deceleration are sufficient). If the initial acceleration is immediately followed by deceleration, the subject experiences rotation, but this feeling does not persist as long as before and apparent rotation in the opposite direction after the stop is greatly reduced. In the *present series of experiments*, the subject signalled the onset and the cessation of these various effects with a telegraph key.

While the subjective effects are in progress, nystagmic eye movements, consisting of a series of slow compensatory drifts in the direction opposite to the experienced rotation followed by a fast recovery movement, may also be observed. These eye-movements were detected and recorded by the corneo-retinal potential technique in one of the experiments to be reported, and in this case the target light was off and the subject was rotated in a dark room. The subjective feeling of rotation and the ocular movements which commence soon after the onset of a stimulus, and which usually persist after its termination, are referred to as "primary vestibular responses."

As will become apparent, some of the results of our experiments (3, 4) have shown surprising conformity with theoretical predictions, whereas other results have shown systematic departures from the theory (5, 6, 7). Figure 2 illustrates the stimulus situation for an experiment which yielded results which conformed fairly well to theoretical predictions throughout most of the range of stimuli presented.

Figure 2 is a schematic representation of (a) 3 of 8 different stimulus situations used in the experiment (upper figure) (b) their corresponding theoretical cupula deflections (middle figure) and (c) the corresponding theoretical response characteristics (lower figure). Note that the angular acceleration (positive slope, upper figure) is the same in all trials but that the deceleration (negative slope, upper figure) was varied between trials. As indicated by the dashed comparison lines, it is apparent from these figures that there is a theoretical relationship between the magnitude of the deceleration and the time elapsed, t_r, between the end of the acceleration and the end of the reaction which was initiated by the acceleration. In essence, our experiment consisted of using a 'standard' acceleration, and measuring interval-t_r when this standard acceleration was followed by different magnitudes of decelerations, the purpose being to determine how the measured interval compared with the theoretical predictions of the interval.

The results of this experiment are presented in figure 3. Slide 3 shows that the points of termination of nystagmic eye movements and of apparent rotation with each of the various magnitude decelerations used were about the same, except for those obtained with the zero deceleration i.e., when the acceleration was followed by constant velocity, and that the results adhered to the theoretical curve fairly closely. The eye movement data and the subjective data were obtained from two groups of 6 subjects with only 2 subjects participating in both experiments.

However in spite of this fairly close correspondence between theoretical and obtained results, the discrepancy between the ocular and subjective reactions at the zero deceleration (where the cupula, deviated by the acceleration, was left to return slowly to resting position by its own elastic properties), and observations in other experiments, led us to suspect that adaptation effects modify any simple relationship between cupola position and response intensity whenever the vestibular system is maintained in heightened activity for more than a few seconds. The experimental situation for an experiment which suggests the presence of this complicating factor is illustrated in figure 4.

Each experimental trial commenced with a low rate of acceleration to some precalculated velocity, which was maintained until the primary vestibular reaction to the acceleration had subsided and for an additional 30 sec. At this point, deceleration was commenced. The plan of this *experiment* was to use a series of 6 decelerations differing in rate, with the duration of each deceleration calculated to produce the same theoretical cupula deviation. Under these circumstances, the higher rates of deceleration would be applied for shorter times than the lower rates, thereby providing differential times (of heightened activity) for adaptation to develop. Since all decelerations were calculated to produce an equal cupula deviation, the time for return of the cupula, upon termination of deceleration, to its threshold zone should be identical for all decelerations. Hence, in the absence of adaptation effects, the

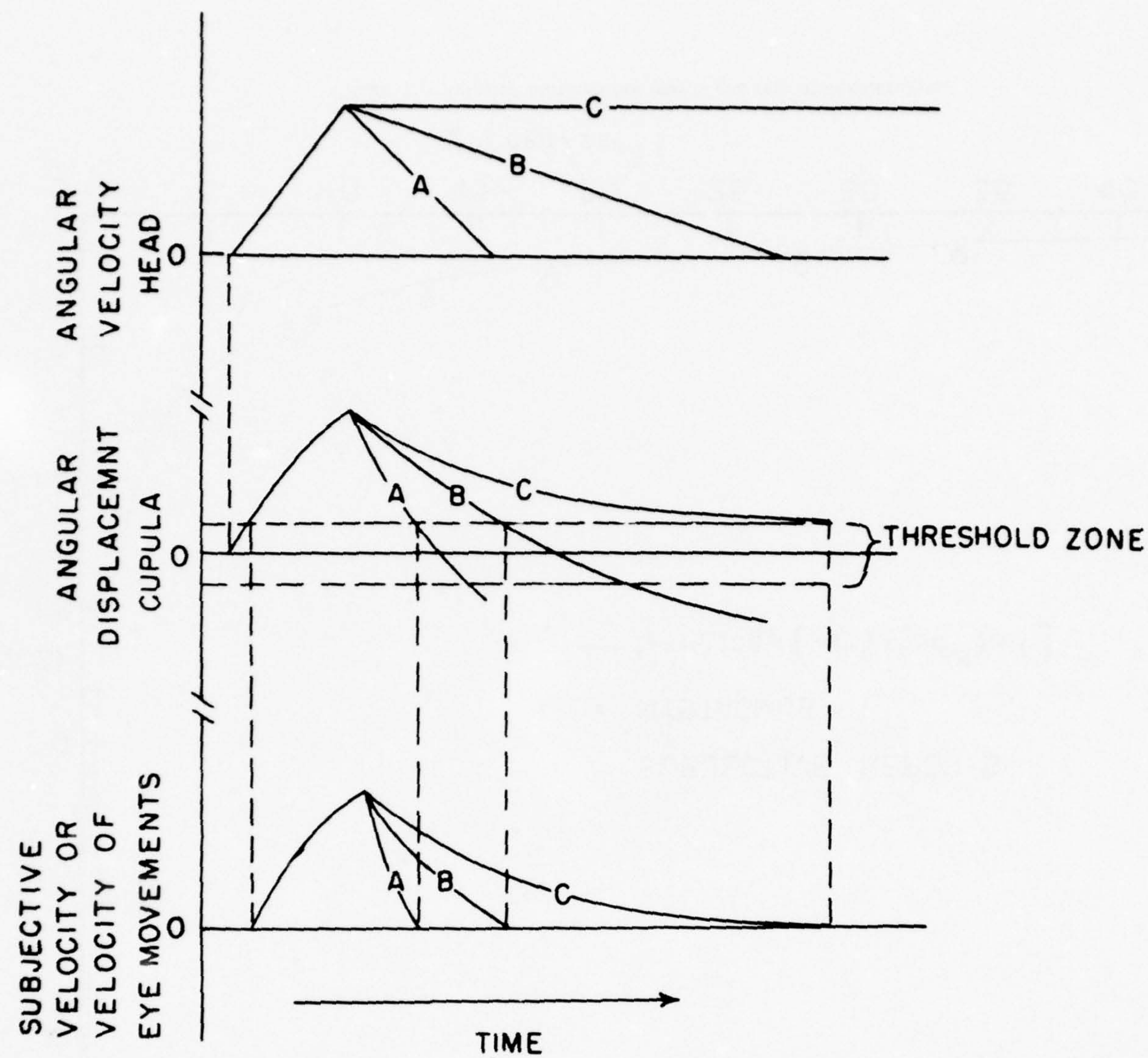

Figure 2. --Cupola displacements, and subjective velocity experiences and eye movements, theoretically expected from three rates of angular deceleration following angular acceleration.

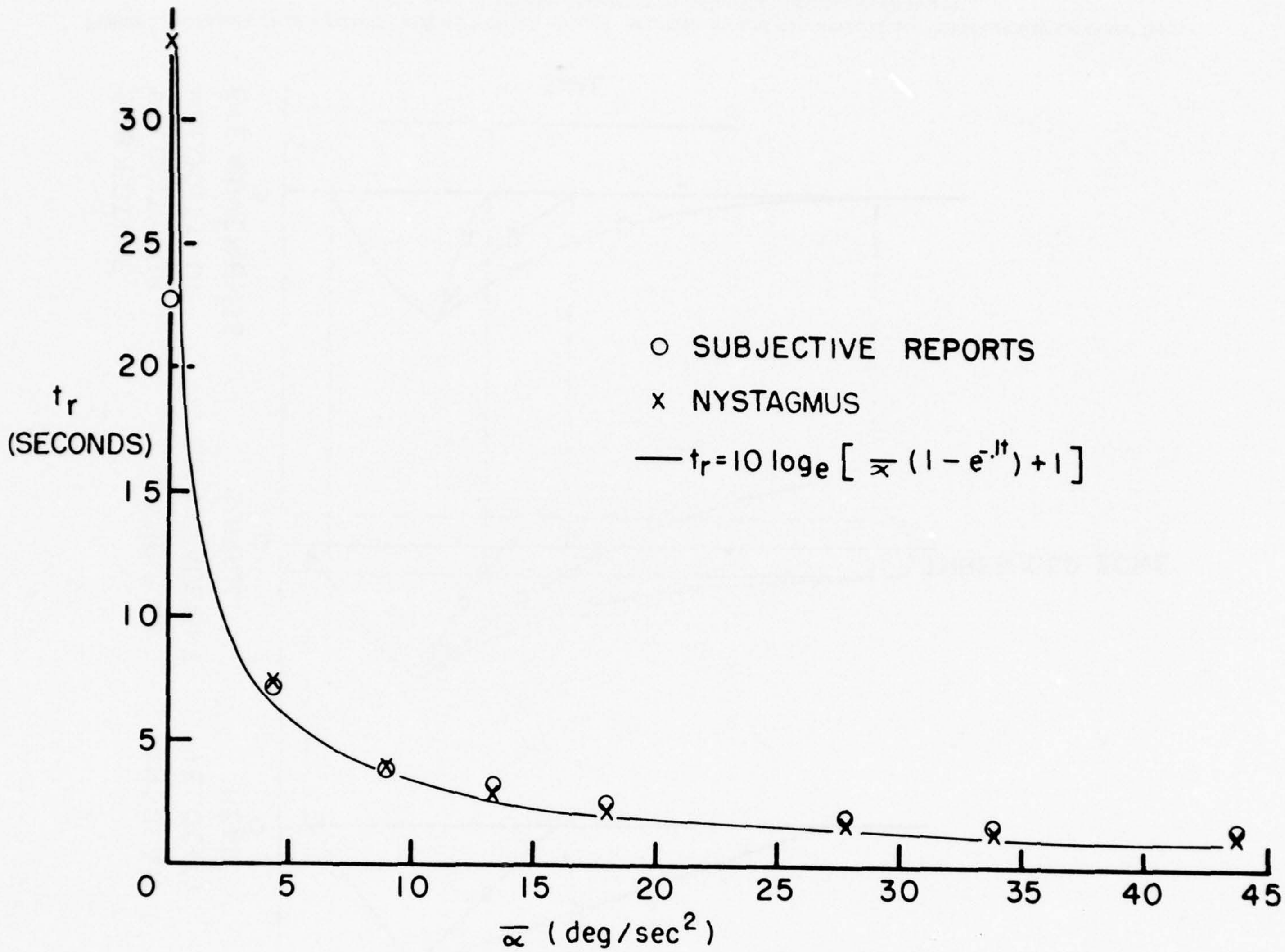

Figure 3. --Relation between interval t_r and rate of deceleration.

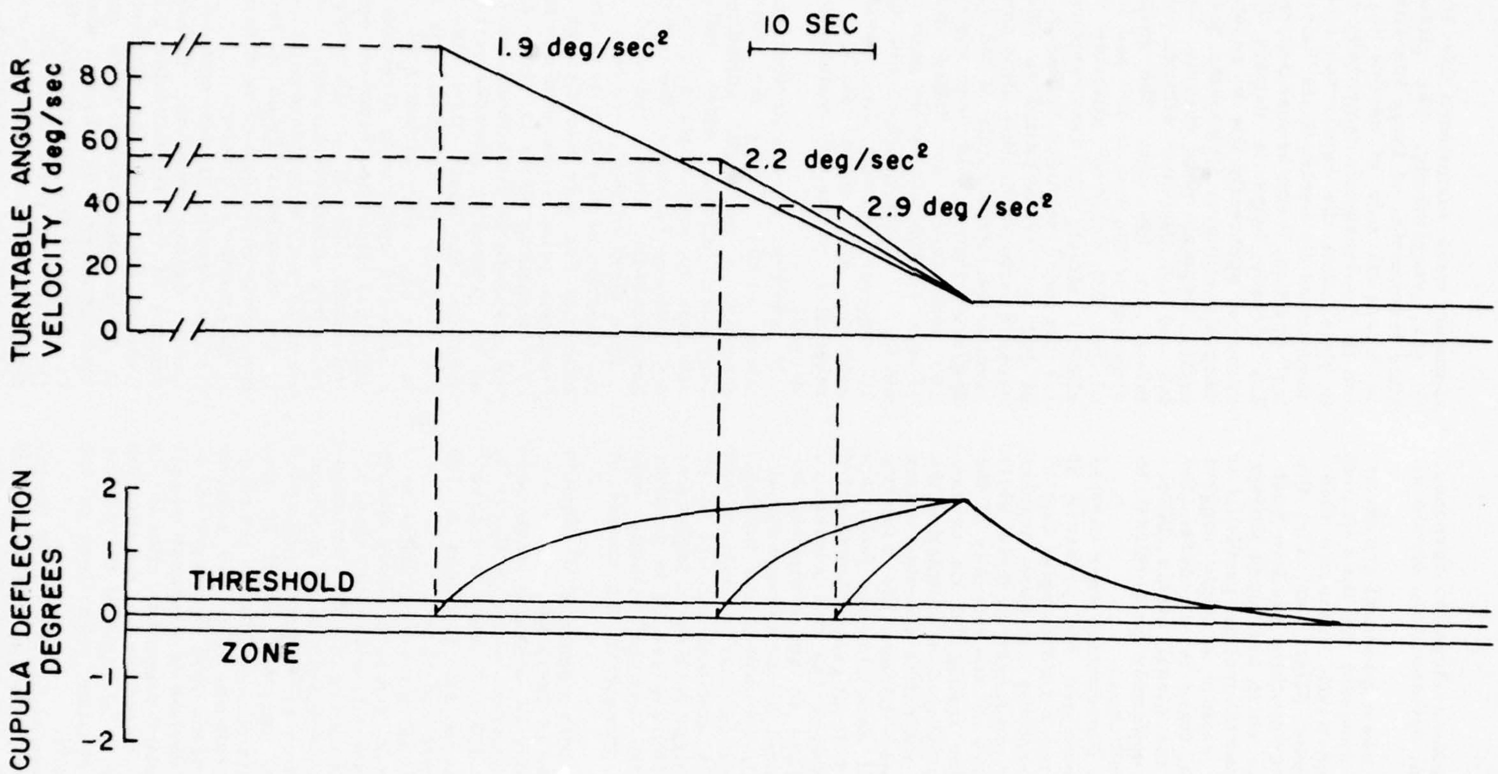

Figure 4. --Examples of various decelerations and theoretically resulting cupola deflections.

duration of the post-deceleration response, t_u, to the different decelerations should be equal.

The results of this experiment are shown in figure 5. It is apparent that the obtained data differ systematically from the theoretically determined points and that the longer-applied decelerations produce post-stimulus reactions which are much shorter in duration than the theoretical predictions.

Although these results strongly suggest adaptation effects, there is, of course, the possibility that the actual cupula deflections were not uniformly proportional to the theoretical predictions.

However, other experiments were carried out which demonstrated the presence of adaptation even more convincingly. One of these involved applying constant angular accelerations for prolonged periods while obtaining estimates of the intensity of the subjective reaction throughout its course. The method we employed in estimating the intensity of the subjective reaction seems to have good possibilities. The subject's task is to signal each time he feels that he has rotated through some preselected angle. Time between any two successive signals should then be approximately inversely proportional to the average subjective angular velocity within the interval. With the assumption that a subject can maintain a fairly constant concept of an angular displacement such as 45 degrees or 90 degrees or 180 degrees, it is possible to plot subjective angular velocity with respect to time throughout the course of the reaction.

This was done with a group of 10 subjects with results shown in figure 6.

Four magnitudes of stimulus were used to produce the results shown in figure 6. They were 0.5, 1.0, 1.5 and 2.0 deg/sec^2 applied respectively for durations of 100 sec, 100 sec, 70 sec and 55 sec.

Considering these times of application of the various stimuli, figure 6 shows clearly that subjective velocity rises and then declines during the course of a constant angular acceleration. Within the range of stimuli applied, 'rise' time to maximum subjective velocity appears constant, about 30 sec, regardless of stimulus magnitude; the magnitude of the maximum subjective velocity attained is dependent upon the magnitude of the stimulus; a decline in response magnitude during constant-magnitude stimulus is present with all magnitudes of the stimulus employed; and time of onset of the decline appears to be constant regardless of the stimulus magnitude.

A point of interest in figure 6 is the increased rate of decline of the subjective velocity after the stimulus terminates (the dotted lines). It will be recalled that the 1.5 deg/sec^2 stimulus and 2.0 deg/sec^2 stimulus were maintained for 70 sec and 55 sec, respectively. The plotted points after termination of these two stimuli show an increased rate of decline in response and this corresponds temporally to a point in time when the cupola has theoretically commenced its return to its "non-stimulating" position. It can be seen that the response has already begun a decline during the stimulus, apparently due to adaptation, and when the stimulus terminates, the response begins dropping more sharply. Each of the 0.5 and 1.0 deg/sec^2 stimuli were maintained for 100 sec. The magnitude of response is too low at 100 sec in the case of the 0.5 deg/sec^2 stimulus to show a similar effect, but the response to the 1.0 deg/sec^2 stimulus, although very low at 100 sec, is sufficient to show the increased rate of decline after the stimulus terminates. Presumably if the 1.5 and 2.0 deg/sec^2 stimuli had been maintained for 100 sec, curves for these stimuli from 55 sec to 100 sec would have been more similar to those obtained with the 0.5 and 1.0 deg/sec^2 stimuli, i.e., would not have exhibited the sharp decline after the respective points of termination of the stimuli.

In addition to the decline in response which occurs during the course of a stimulus, a prolonged stimulus produces adaptation effects which influence the response to subsequent stimuli even after the primary effects of the initial stimulus have subsided. This is indicated in figure 7.

Each point in the lower curve represents the duration of response to a standard test stimulus. The only condition which differed from one point to the next was the duration of a preceding stimulus. It can be seen that the response is diminished more and more as the preceding stimulus is increased in duration. The upper curve also represents the response to standard test stimuli but in this case, each stimulus is preceded by a stimulus opposite in direction to the test stimulus. Here the responses appear to be influenced little if at all except when the preceding stimulus exceeds a duration of about 25 sec, and at this point the response to the standard stimulus is increased by the effects of the preceding stimulus.

To summarize briefly:

(1) The results of our completed experiments dealing with the theoretical mechanics of the semicircular canal system indicate that when the vestibular system is driven about as it is in routine daily circumstances, i.e., through short arcs as in normal head movements, the reaction is consistent, predictable and behaves as though it were controlled by a cupula mechanism with the characteristics of a damped torsion pendulum. When the system is driven for a long time, some process develops

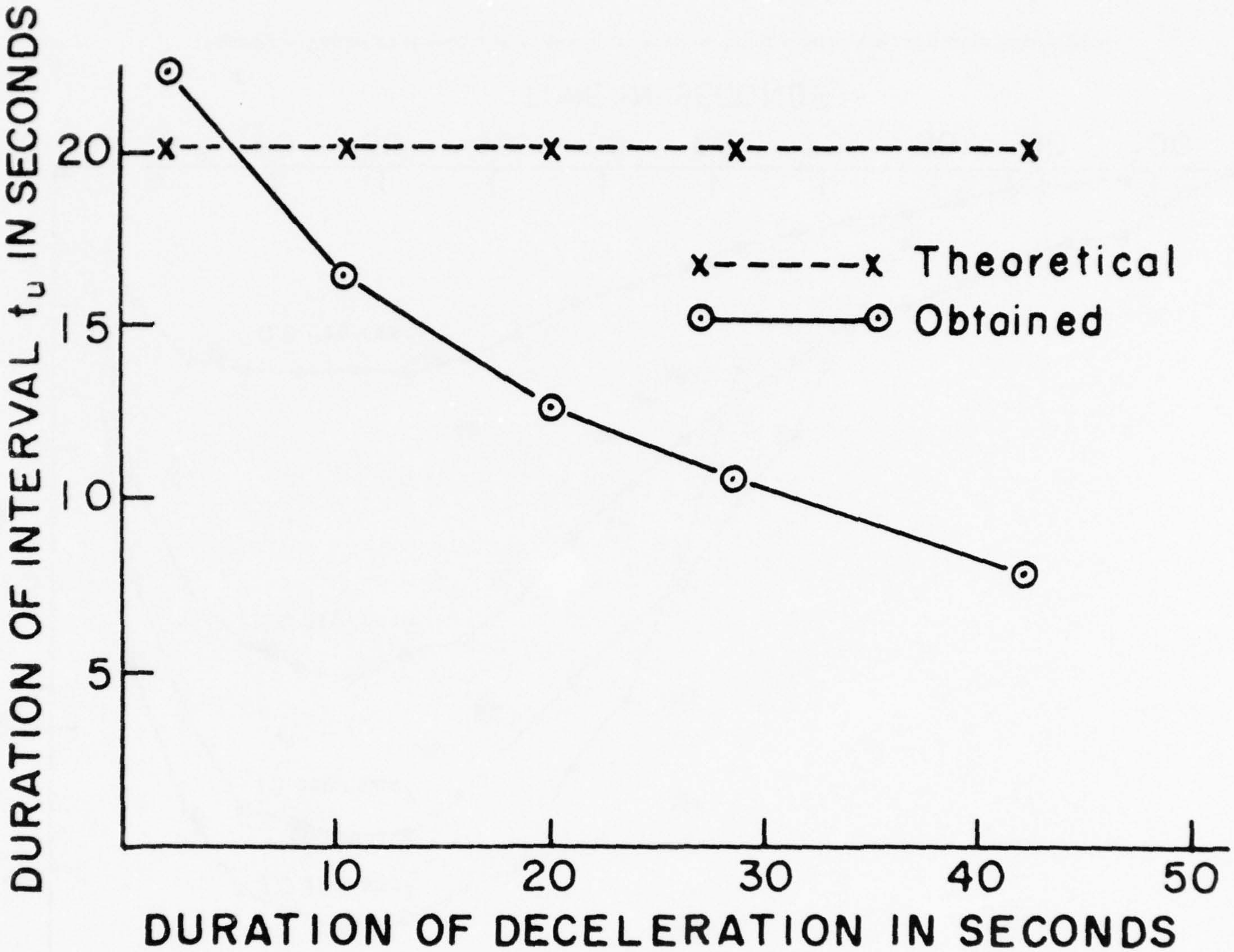

Figure 5. --Comparison of expected and obtained relations between durations of deceleration and of post-deceleration response (t_u).

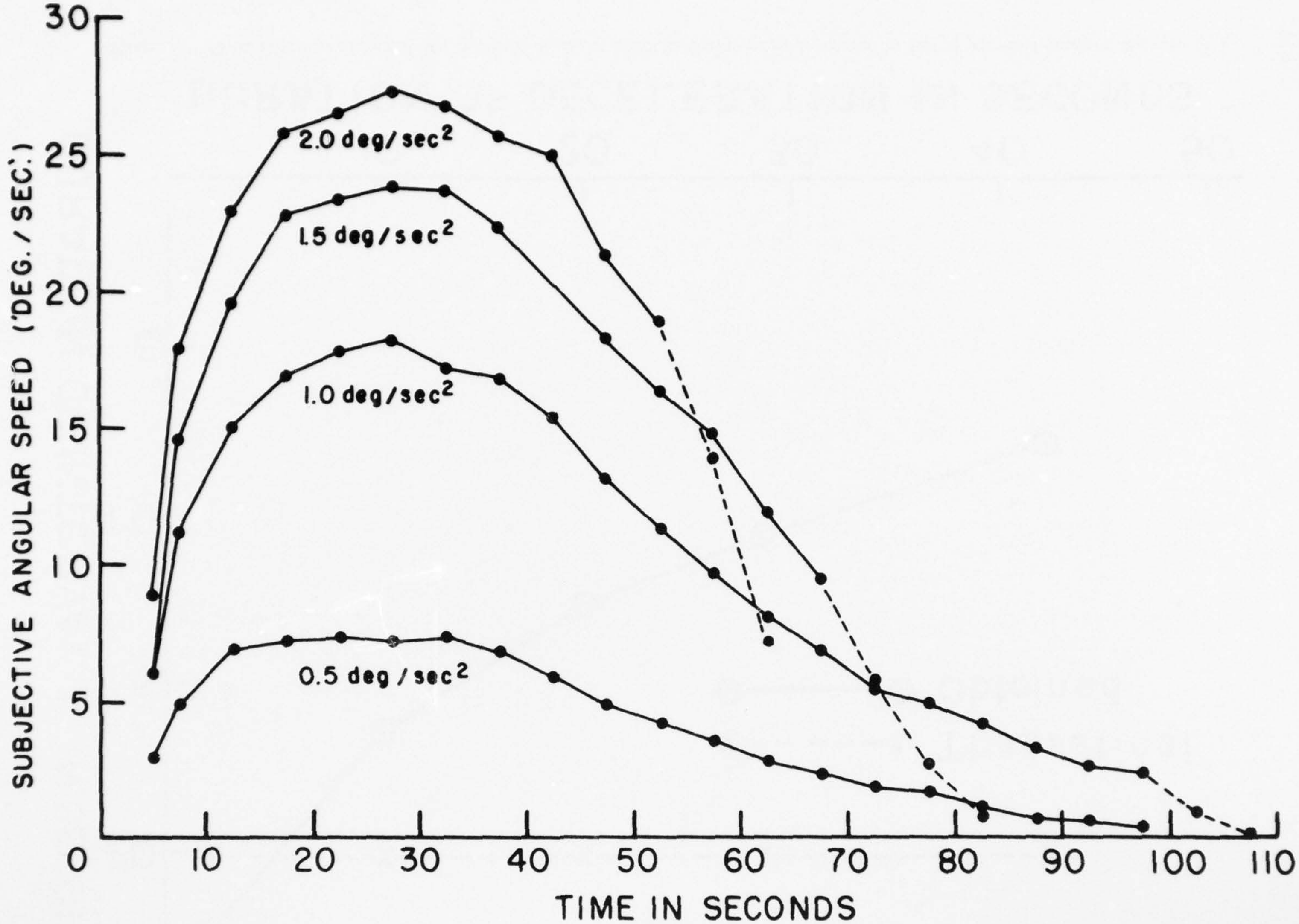

Figure 6. --Variations of subjective angular speed reported during constant rates of angular acceleration.

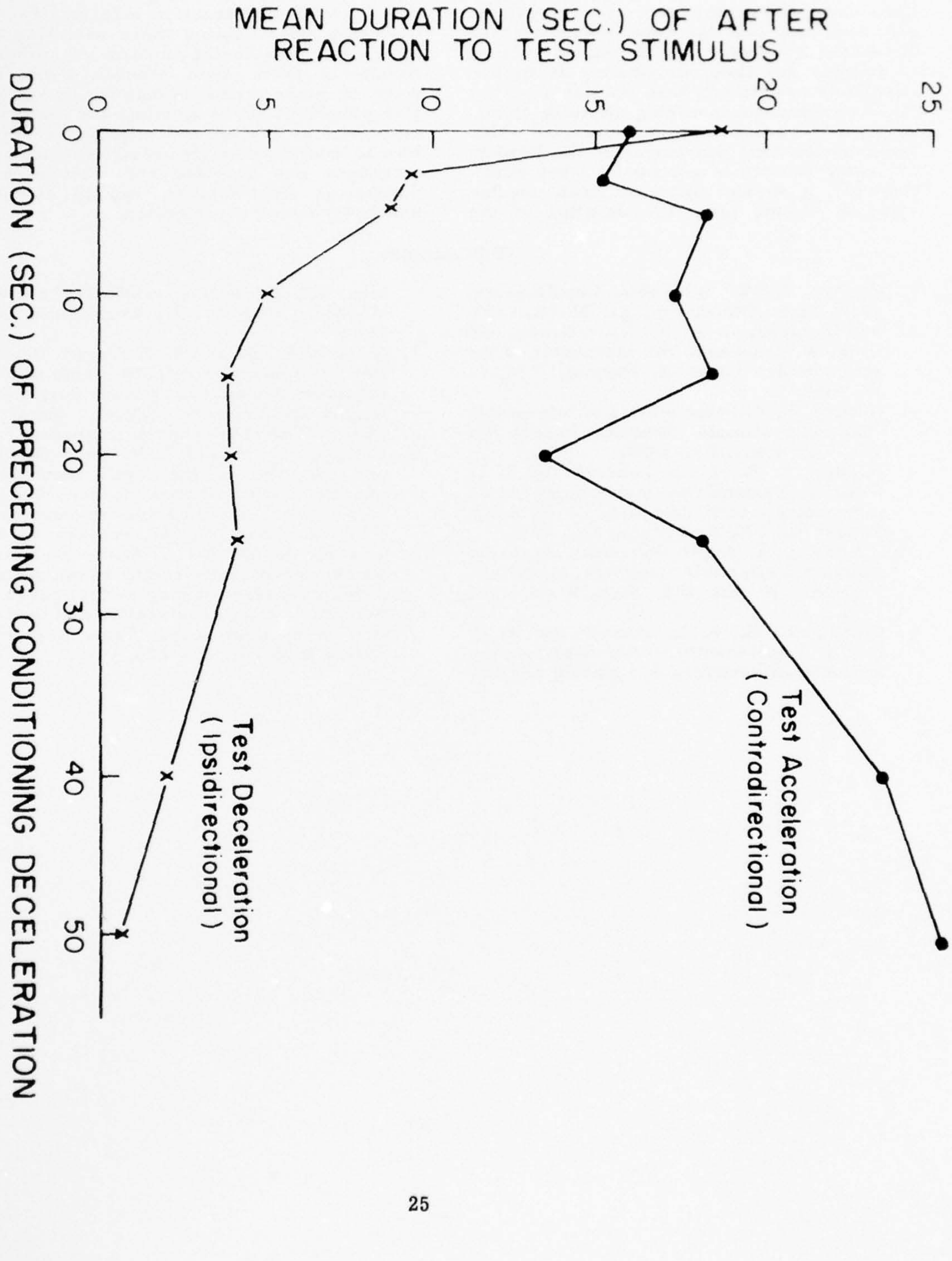

Figure 7.--Duration of after-reaction in relation to duration of preceding ipsi and contra-directional angular deceleration.

during the reaction to alter the intensity and the cut-off point of the reaction. This process has greater effect as the duration of the stimulus is prolonged, and under these conditions the reaction does not follow predictions based upon the theoretical mechanics of the end-organ. The deviations themselves, however, appear systematic and, now that the conditions for these deviations are becoming known, our ability to predict reactions originating from the vestibular system has been increased.

(2) Our research involving Coriolis accelerations suggests that any situation which requires frequent movement of the head in a turning vehicle is potentially a bad situation for a human operator. The angular velocity of the turn, the duration of the turn, the angular acceleration which initiates the turn, the time elapsed between the cessation of angular acceleration and the initiation of the head movement, the kind of head movement made, and the visual orientation cues present are all relevant variables in determining the intensity of the Coriolis acceleration effects. We are currently investigating these variables and are also considering means of reducing ill-effects from such stimuli. From our work on these problems thus far, it appears that situations which simulate the vestibular detectors of linear and angular acceleration in such manner that conflicting sensory messages are provided are potential producers of disorientation, motion sickness and faulty motor coordination.

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V. U.S. ARMY ORDNANCE CORPS PRESENTATIONS

"ORDNANCE DESIGN CONCEPTS FOR GROUND MOBILITY"[1]

by
Dr. Donald Wylie
Office of Ordnance Research, U. S. Army
Box CM, Duke Station, Durham, N. C.

There is no dearth of material on the assigned subject; the difficulty in preparing a brief talk is one of organization. The R&D being prosecuted by Ordnance toward increased mobility is so varied and the results are so inter-related that one must consider the picture as a whole and not single out any one facet to the exclusion of others. Too, an improvement in ground mobility might very well have been initiated, for example, by a desire to make some item of Ordnance equipment air transportable. To simplify my task I finally decided upon the very basic idea of working "from the ground up."

Since the start of recorded history man has been busy expediting his overland movement through the development and extension of highways and railways. For peaceful pursuits this approach to mobility is quite adequate; however, armies must leave the smooth roads. In fact, the necessity for development of cross-country transportation increases with improvement in the art of warfare, when dispersal of forces and materiel becomes mandatory.

An answer to the question of how to go about improving cross-country mobility fortunately may be found in several precedents. Early flights were undertaken without much knowledge as to how to shape wings and fuselage to obtain maximum efficiency, i.e., the maximum of lift-drag ratio; later development of aerodynamic theory solved the problem. A similar condition existed in naval architecture until the advent of modern hydrodynamic theory. Thus it may be deduced that automotive engineering must also develop a formal discipline which will help produce vehicles that give the maximum load-thrust ratio in a given medium of operation. Such a discipline has been practically non-existent beyond crude empirical know-how, and its establishment has been one of the major goals of the Land Locomotion Research Laboratory of the Ordnance Tank-Automotive Command.

In a number of seminars sponsored by various groups and organized by this Laboratory, the definition of the problem and the method proposed for its solution were widely popularized and led to gradual recognition that the new research originated by the Army may also be of benefit to the civilian economy. The general method of attack and the problem itself, formulated in the above way, have already attracted the attention of universities and industry. The University of Michigan has established new graduate courses and laboratory activities within the curriculum of automotive engineering; and industry has expressed interest by establishing, within the Society of Automotive Engineers, an "Off-Highway Vehicle Mobility Advisory Committee."

To plan design operations and to decide whether or where tracks or wheels may work economically, an exact knowledge of pertinent soil values is indispensable. Knowledge of soil values may lead to new and superior design concepts. Comprehensive evaluation of the travel efficiency of various tire sizes and tracks in various soils cannot be performed without the determination of pertinent soil values.

Soil-value theory has led to the discovery that tracks should be made with links spaced at specifically-determined distances, instead of cleats mounted so close to each other that they form a continuous band. This contradicted well-established design trends and led to what now may be considered a rule, namely, that not only the size of the ground contact area, but also the form of that area, is important.

Here we might call attention to an example of payoff in one field resulting from research conducted in another. The new spaced-link concept was applied to design of artillery spades and a worthwhile saving in weight without lessening of effectiveness became apparent.

[1] Dr. Wylie's paper, classified SECRET, is here rendered in an unclassified paraphrase. Properly authorized individuals or agencies may obtain a copy of the full text by application to the Army Research Office, Attn: Human Factors Research Division, The Pentagon, Washington 25, D. C.

Since a sizeable portion of the earth's surface is periodically or permanently covered with snow, studies are now being made to determine the various characteristics of this material in connection with the design of vehicles for use thereon.

An additional use of these studies resides in the construction of trafficability maps. Such maps are valid in limited meteorological conditions. Precipitation and temperature variations change trafficability values with time. The physico-chemical mechanism of such changes is in itself an enormously wide field for investigation. The relevant problems must be separately and then collectively studied if the full advantage of a soil trafficability map in variable meteorological conditions is to be realized. Thus in the final analysis, the problems of soil and snow mechanics are linked with physico-chemical research, in which meteorology is assuming the same importance as it does in the field of aeronautics.

Having considered the surface on which much of our movement must take place, let us consider some vehicles which may operate on this surface to move the vast tonnages required in warfare. While the problems confronting the Ordnance Corps are frequently quite specialized, we are not averse to adopting ideas from outside sources which we believe to be applicable. Call to mind the frequent appearance of earth-moving equipment literally moving mountains over cross-country conditions. The more obvious features of this equipment are large-diameter low-pressure tires and 2-wheel prime movers with wagon-steering. Less apparent, but none-the-less desirable for Army operation are rear-wheel traction, exoskeletal structures permitting floatability, and high ratio of payload to gross weight.

Ordnance Corps efforts to increase mobility are illustrated in some achievements in improved rocket launchers, rocket handling equipment, and self-propelled artillery. As an example of the study which goes into an analysis of weight-reduction potentialities, let us consider in some detail a recently completed study made to determine the feasibility of reducing the weight of the XM-33 "Honest John" launcher to a level consistent with efficient helicopter transportability, while retaining the desired performance requirements of firing stability and reproducibility, air drop capability, and ground mobility.

This study was an extension of the development of a helicopter-transportable "Honest John" rocket launcher, which culminated in the testing of three pilot models at White Sands Missile Range and Ft. Bliss. The performance criteria were as follows:

a. For efficient helicopter transportability, the gross weight should not exceed approximately 2,500 lbs. (The weight of the pilot-model launchers plus additional weight added to meet ground mobility criteria was of the order of 3,800 lbs. This weight required the use of two of the helicopters presently available, or the use of one larger-capacity helicopter not yet in general production.)

b. For ground mobility, the launcher must be capable of being towed cross-country without the rocket.

c. For rough traverse (traverse greater than the ± 10 degrees built into the launcher), the launcher with the rocket loaded must retain sufficient mobility to permit 180-degree traverse.

d. For air drop operations, additional locking mechanisms, as found necessary in the air drop tests, must be included as part of the launcher. The weight reduction required (on the order of 1,300 lbs.) dictated the use of the lightest-weight material generally available for structural purposes. Aluminum alloy met these requirements best.

This study showed that major emphasis needs to be placed on structural re-design to improve the efficiency of carrying the required loads. Proposed structural rearrangements consisted of prudent location of transport points, more efficient distribution of structural material, and elimination of inefficient use of materials.

Certain problems which arise from the use of aluminum alloy as the structural material were considered; the major problem results from the lack of hardness of aluminum alloys. This fault may be overcome by applying bronze wearing surfaces to the aluminum alloy where sliding surfaces are required, such as in the rocket guide rails and at pins. Further study is required to determine the suitability of bronze wearing surfaces and also to determine the possibility of using other materials for a coating to provide the necessary surface hardness and wearability.

Another problem involves the weldability of the aluminum alloy. It was assumed that suitable welding methods could be adopted which would permit the production of a satisfactory structure by welding. The results of the feasibility study on weldability indicated that a launcher weighing on the order of 2,500 lbs. and meeting the established criteria could be developed.

In connection with mobility of the Corporal rocket system, Ordnance engineers have visualized an apparatus incorporating the "Goer" principal. This comprises a combination erector, servicer, and launcher. The basic concept incorporates:

a. Large-diameter low-pressure tires, which increase ground clearance, eliminate the need for suspension system, provide

better vertical obstacle-crossing ability, and decrease rolling resistance and increase traction.

b. Positive-power and wagon steer. The phrase "wagon steer" is derived from the fact that the entire axle swings and carries the wheels in a manner similar to that of a farm wagon. The phrase "positive power" refers to the fact that the driver has complete and positive control over the axle position anywhere within the desired limits of travel. The positive power wagon steer arrangement also eliminated vehicular "rack," i.e., the transmission of stresses between the prime mover and the wagon.

c. A clean under carriage, having no articulating driving linkage.

This type of Goer vehicle has a payload to gross weight ratio of about 50 to 70%, as compared to the standard vehicles which operate in ranges of 25 to 40%. One Goer principal missing from this concept is the ability to float.

Another adaptation of the Goer principal is reflected in the Squatter vehicle concept. This vehicle will have:

a. variable ground clearance that enables the hull to be lifted in deep mud, thereby reducing ground resistance. It also provides for a low silhouette and protection for the wheels in battle.

b. troop protection from small arms fire.

c. hydro jet propulsion as the propelling force when afloat.

d. compatibility with Phase 1 airborne operations.

e. a smooth bottom since there is no articulating driving linkage.

f. good firing stability when the hull is resting on the ground.

g. a short-turning radius because of the 180 degree pivot of the third wheel.

h. a short emplacement and displacement time due to the hydraulic linkage that forms the elevating and suspension system for the vehicle. A feasibility study of an auxiliary-propelled 155 mm howitzer carriage is being made to determine the capabilities of incorporating motor units (electric, hydraulic) in its wheels, so that it can propel itself independently of a prime mover. This weapon system should have advantages in an airdrop operation.

Let us now consider the efforts of our cannon people to increase the mobility of the Army. Here there would seem to be wonderful opportunities to effect a reduction in weight. As you will see, not only are accomplishments along this line anticipated, but also other aspects are being considered simultaneously to increase the overall mobility-effectiveness product.

Through research being conducted in several facilities the Ordnance Corps is making significant strides in lightening the weight and increasing the effectiveness of artillery items for troops in the field.

One of the critical features influencing the mobility of our armed forces involves the armor. Here the opportunities for weight saving and effectiveness are tremendous. Air transportability may or may not be possible depending solely upon the solution of this problem in specific cases.

A comprehensive program of research and development devoted to lightweight materials for armor and structures is currently under way. Particular emphasis is being placed upon the use of alloys of aluminum and magnesium; significant though less extensive efforts are being devoted to casting titanium alloys and to the fabrication of so-called ultra-high-strength steels. The emphasis placed upon aluminum and magnesium is at once a consequence of the use of non-ferrous metals and of the fact that weight reduction is possibly the most direct road to increased mobility.

Interest in aluminum as an armor material lagged for a time but was renewed a few years ago when the lessons of Korea were evaluated and a new urgency was attached to increased mobility. On the basis of the lessons learned, emphasis was shifted from protection against AP shot (except small arms fire) to protection against explosive shell fragments. In the new context, aluminum appeared to have distinct advantages over steel both from a fragment protection standpoint and as a significant weight saver. The decision was made, therefore, to design and construct an over-all aluminum, all-welded personnel carrier that would save 15 to 20 per cent in weight over its steel (1/2" thick) counterpart.

At this writing, a prototype vehicle of the aluminum magnesium alloy weighing significantly less than its steel counterpart has been built and tested for resistance to shell fragments. The results are not as good as had been anticipated, but they are by no means discouraging. Since this single test, the alloys have been improved. Continued close cooperation with the major aluminum manufacturers promises to provide alloys that will satisfy the high ballistic standards required by Ordnance.

Within the past two years or so, alloys of magnesium-lithium have emerged as a promising armor material. A vehicle constructed of this alloy will provide a weight saving 15 to 20 percent greater than its aluminum equivalent. The decision to build a vehicle from magnesium-lithium was preceded by several years of intensive laboratory work in which the properties and behavior of this low density material were evaluated. Plates of the required thickness are now being rolled for later incorporation into the carrier structure. Should this venture

be successful, it would constitute a major step forward toward increased mobility.

It would seem to be appropriate to consider the incorporation of these materials in other items of Ordnance. Aluminum castings provide an excellent example of the strength gains and increased structural integrity and reliability made possible through advances in foundry technology.

The acceptance of this new material has been retarded for two reasons. Primarily current foundry practice develops only about fifty per cent of the inherent strength in the high-strength aluminum alloys. Secondly, the large variation in properties from one casting to the next has established a low confidence level among designers. As a result, the safety factor and over-designing necessary to insure against service failure considerably reduced the weight-saving potential.

The development of a new foundry technology is still in its early stages. However, based on the results to date, several commercial foundries in this country are currently producing "quality castings" and guaranteeing properties in the casting (not just in a separately cast test bar).

Another activity concerned with decrease in weight as well as size is the development of propellants. Double-base solid rocket propellants are being developed which have higher specific and volumetric impulse in order to decrease the weight and volume of propellant and motor required to accomplish a given mission. Likewise, smokeless-flashless artillery propellants having higher force levels than those presently in use are being developed to permit a smaller chamber volume and consequently lighter-weight guns.

An interesting example of research for increased effectiveness and mobility is the design of the cartridge, HE, T388, 105 mm howitzer to eventually replace the standard HE, M1, 105 mm. This round utilizes the hollow-base concept to increase effective chamber capacity. A substantial increase in muzzle energy is obtained, enabling greater ranges to be achieved. Proper design and zoning of propellant charges also will possibly reduce the minimum and increase the maximum range capability. The hollow-base round also has the rotating band located at the rear of the explosive cavity; this lowers the shell stresses and permits thinning the ogive walls, increasing HE capacity (hence lethality) and reducing projectile weight by approximately 10%.

The Ordnance Corps has for a number of years been investigating combustible cartridge cases for artillery ammunition. The advantages expected from the combustible case include:

a. Elimination of noxious fumes in tanks

b. Elimination of the problem of spent-case disposal

c. Decreased weight.

The combustible case is necessary for guns having lightweight self-obturating breeches because metallic cases present serious extraction problems. The combustible case, which permits higher loading densities, makes maximum reductions in ammunition and gun size and weight probable.

Atomic warhead adaption kits are now one-third the weight and size of those in existence when the Ordnance Corps took over this responsibility approximately five years ago.

One further technique now under consideration for reducing the weight and size of adaption kits resides in the design of major components to perform their functions directly rather than through secondary components; for example the elimination of relays in the functioning of switches through the use of explosives or barometric switches. Studies are being conducted to reduce structural weight and size by:

a. Eliminating the housing of individual components and relying on a single housing to protect all components.

b. Employing new metals and materials such as titanium, beryllium, magnesium alloys, honeycomb structural metals and plastics, and adhesives having very good strenght-to-weight ratio; and

c. pressurizing aerodynamic structures.

The miniaturization of components involves the redesigning of existing components as well as exploring other new concepts. Some of the main areas where effort is being expended include devices for shafting, arming, fuzing, improving power sources, and bettering circuit techniques, and structures.

One of the new concepts under study in power sources involves the use of ferroelectric and ferromagnetic materials to supply a large quantity of high voltage electrical energy very rapidly. Through the use of these and similar techniques, it may be possible to eliminate several complex components presently required to accomplish the same result.

Effort is also being expended toward the development of new weapon systems designed for lightweight ammunition and ease of handling. The SAP weapon system, which falls in this category, was conceived to provide maximum fire power with minimum weight. It has the potential of firing a projectile at velocities of 60000 ft/sec from a platform small enough to support only the weight of the firing tube.

Several current innovations in the field of small arms ammunition should permit the development of much smaller and lighter infantry rifles in the future. These consist of (1) very small cartridges firing dart-like projectiles and (2) solid and liquid

propellant systems which will eliminate the need for the metal cartridge case. These improvements will not only offer savings in the weight of ammunition carried, but also should permit rifle redesign for shorter bolt action and elimination of the ejection cycle. It is reasonable to expect these changes to effect a drastic reduction in rifle weight together with an increase in weapon effectiveness.

Another contribution towards increased Army mobility resides in the design and development of improved ammunition packaging materials, to withstand environmental, handling and storage factors, to prevent ammunition damage, and to provide optimum design features (size, shape, etc.) for ease in loading and handling by troops.

One outstanding program being pursued toward reduction in weight and cost calls for an intensive investigation of plastics as lightweight construction material. Items for which plastics have been or are being evaluated are:

1. 300 gallon tanks for drinking water
2. ammunition boxes
3. jato body
4. mortar base plates
5. components for missiles (Atlas, Thor & Jupiter C)
6. cases for missile tracking flare
7. nuclear radiation shields
8. gun shields for 110 mm howitzer
9. "Hawk" missile warheads
10. atomic weapon casings
11. propellant charge extensions
12. propellant case closing plugs for 155 mm gun
13. 81 mm illuminating shell bodies and tail cones
14. polyethylene closures for igniters
15. various packing containers

Work is in progress to determine the mechanical properties of plastics when these materials are subjected to stresses which vary in duration from a few milliseconds to a year. The effects of environmental conditions and extremes of temperatures on the mechanical properties of plastics are also under investigation.

Information obtained from the above work should permit more effective use of plastics in materiel; e.g., present plastic items may be overdesigned and heavier than necessary. Accurate information on the mechanical properties of plastics may allow the design engineer to reduce the weight of his plastic item. Such data will result in a still greater weight saving by the utilization of plastics in field equipment.

Materials of commercial manufacture frequently are incapable of meeting the stringent service requirements set by Ordnance. Experience indicates, however, that most commercial alloys possess the capacity for improvement in mechanical properties to a degree that can satisfy Ordnance requirements. Essentially it is this potential for improvement in properties upon which our approach to materials research and development is based. Knowledge of both a fundamental and applied character is required if the full potential of commercial materials is to be realized. Our materials research program is designed to provide the necessary new information.

Gradually being inserted into the program are projects to investigate materials that are now in the early experimental or conceptual stage. Beryllium and silicon are two examples of elements being considered as the basis for practical alloy systems. A number of other elements are equally attractive because of their unusual properties. Modification and adaptation of such "bad actors" to Ordnance use will be no simple matter, but certainly the effort must be made in the interests of increased mobility.

Titanium alloys are particularly attractive because they offer the highest strength to specific gravity ratio of all the commercial structural alloys. This desirable property, accompanied by good ballistic properties, is an excellent reason for utilizing titanium alloys in ordnance applications.

Recent advancements in vacuum arc melting furnaces, and the development of a satisfactory rammable graphitic mold material, have provided the necessary prerequisites for a commercial titanium casting process. These technological advancements have made possible the production of shaped castings weighing up to 200 pounds. An alloy steel casting of comparable size would weigh approximately 350 pounds.

Greater weight reduction can be realized when titanium alloys are substituted for the heavier non-ferrous alloys, for example, the brasses. A substitution of this type also permits size reduction because of the strength differential of the two types of alloys. It must be acknowledged, however, that titanium is still a very expensive material, and where cost is a factor, caution in its use must be exercised.

Illustrative of the close connection between design and materials is an innovation which bears the descriptive name, "cellular aluminum." Materials ranging in density from 35 to 65 pounds per cubic foot can be made. The process consists of preparing a sand mold of the desired shape, filling the mold with a properly graded and suitably selected soluble salt, and infiltrating the salt with molten metal. Upon solidification, the cast shape can be further machined to close tolerances and the salt leached out to leave the lightweight structure. Since the cells are interconnecting, the material can be easily heat treated to improve its properties. Air or liquid can be passed through it with great facility.

At present, work is being done to determine the effect of such variables as cell size and distribution, alloy composition and heat treatment on the mechanical properties of the material.

Alloy formulation is but one aspect of the overall materials development program. Frequently, it is a fabrication method, joining technique, or corrosion protection system that holds the key to successful Ordnance application. Considerable attention is consequently being devoted to these aspects of materials utilization.

From an engineering standpoint, structural materials and structural design cannot be considered as unrelated contributors to a common objective; for, in fact, the two are intimately related. Design considerations often act as the spur to materials development and vice versa.

In more subtle ways, as in the selection of a method of fabrication for a particular item, materials and design considerations again interact strongly. (A good casting design may be a total failure as a forging.) To neglect this interplay between materials development and design innovations would be most foolhardy; rather, every effort should be made to foster a closer relationship.

A great deal of work is being done by the Ordnance laboratories toward the development of high quality joining techniques for lightweight armor materials. These materials are intended primarily for use in airborne armored vehicles, and joining of the armor is a critical problem.

A second large area of investigation in the field of metal joining involves the corrosion effects of inhibited red fuming nitric acid on various welded aluminum alloys, used for storage and fuel tanks of guided missiles. Complete understanding of the influence that certain preselected variables have on the corrosion rate of these tanks in the presence of RFNA will aid in specifying conditions and materials that will effectively reduce missile failures and permit the use of lightweight propellant containers.

A third area of metal-joining research, which also should contribute to reducing the size and weight of Ordnance items, is the ultrasonic welding of metals. Ultrasonic welding requires no filler metals or heat and has been shown to be particularly effective in the joining of very light gage aluminum alloy materials including the thin commercial foils. The possible use for this process have not been fully evaluated but it holds considerable promise for such things as closures for aluminum containers and the joining of light-gage metal structures.

Considerable research and development is involved in the corrosion protection of metals. Much of this effort has and is being directed to the protection of lightweight metals, principally magnesium and aluminum, and to a lesser degree titanium. Great success has been achieved with the anodic protective treatments for magnesium. Work with aluminum has been concerned with improving the seal of anodized surfaces and with the development of improved chemical conversion coatings. Work with titanium is being directed toward developing coating deposits which will enhance its performance at high temperatures through improving the quality and serviceability of electrodeposited coatings.

Development is under way of: aluminum cartridge cases; magnesium ammunition containers; lightweight and smaller plotting boards, aiming posts, binoculars, servos, and synchros; transistor circuitry for fire control; and cartridge-actuated devices for various purposes, such as cable cutting.

Another major area of research which is contributing towards increased mobility involves supplying the users of complex equipment with material that requires only a minimum of check-out. Almost all complex equipment presently under development needs only simple, go, no-go test at the field level. These are often self-contained, thereby eliminating the need for separate test equipment. In the event of a malfunctioning unit, modular replacements eliminate field maintenance requirements and thereby lessen the total weight of necessary spare parts and components.

Since 80% of the weight of material supplied to front line troops is in the form of ammunition, it is essential that none be wasted. During World War II, vast quantities of ammunition were wasted as a result of human error, e.g., misread dials, firing unarmed rounds, failure to arm mines, grenades etc. Ordnance is presently exerting a concentrated effort directed toward eliminating, as far as possible, all human error in the utilization of its items and through recommending designs conducive to increased user speed and accuracy.

Last, but in no wise the least important of the Ordnance-Corps efforts to make the Army more mobile, is that of electronic microminiaturization. As the term implies, the percentage gains in weight reduction are of a much greater magnitude than anything described earlier in this discussion.

Microminiaturization has resulted in electronic subassemblies such as amplifier and flip-flop counter stages constructed through the use of integrated electronic parts. This technique permits discarding the case and leads of the conventional resistor, condenser, diods and transistor, which are of necessity made large enough to permit ease in handling and assembling; and mounting the working parts in and on a small thin ceramic plate. The further development and perfection of microelectronic techniques will result in:

1. two or three orders of magnitude in size and weight reduction.
2. automatic processes in manufacture.
3. more economical electronic systems.
4. more compact, rugged and reliable electronic sub-assemblies.
5. additional compact electronic systems to perform information or intelligence type functions, such as: guidance and navigation equipment for missiles; computers for optimizing fuel consumption in vehicles; small portable data processors and computers.

This type of construction is applicable to operational types of circuits but not to power circuits. The essence of this concept would seem to be "if you can see it, it is too large."

I would like to comment upon an OOR project that may have distinct effect upon mobility; having spent some seven years in field service with Ordnance maintenance outfits and staff organizations, I am quite cognizant of the supply problem in the field and the logistical implications.

A study of the control of the supply of repair parts for Ordnance equipment is being conducted at MIT. A mathematical solution is being sought, employing a stochastic treatment of the large time-variations in demand being experienced at supply points. Work is also involved in further study of types of probability distributions for parts demands to which the optimization techniques may be applied, and which are verified by existing Ordnance data on such demands. In addition, a generalized Monte-Carlo simulation has been constructed, for use in the IBM 704 computer at MIT, for the operation of the general Ordnance depot supply system, under both present and proposed procedures. The mobility of the Army may well be improved by ideas on the supply of repair parts stemming from this statistical research.

Ordnance is continuously cognizant of and designing for improved mobility, employing various devices and techniques, of which the most significant are:

1. reduction in weight
2. reduction in size
3. increased ballistic and terminal effectiveness
4. improved structures
5. new metals and materials
6. new component concepts such as power sources, timers, fuzes, etc.
7. increased operability
8. increased reliability
9. disposable weapons
10. universal and multipurpose devices
11. replaceable module components or assemblies to eliminate maintenance
12. devices for improved transportability

Within the time allotted I have been able to touch upon only some of the high spots in the ever-continuing effort of the Ordnance installations to improve the mobility of the armed forces. While these gains initially appear as isolated factors, they soon reappear as items in a closely-integrated program resulting in new concepts or starting points for further improvements.

VI. U.S. ARMY QUARTERMASTER CORPS PRESENTATIONS

"MINIMAL SUBSISTENCE REQUIREMENTS TO MAINTAIN PERFORMANCE"

by
Dr. Austin Henschel
Quartermaster Research and Engineering Command

The past few years have witnessed a vast change in concepts of military operations and in the tasks that the soldier is called upon to accomplish. Mobility, lightness, austerity, aerial supply, radar surveillance, complicated missile systems and even anti-missile missiles have become key words in the new concepts. Military operations as foreseen will involve relatively isolated, highly mobile combat groups that strike and maneuver under the combined stresses of extreme environments, of new weapon systems and of the pressures of timeliness. Where mobility is paramount, encumbrances with any but the absolute necessities for successful combat operations cannot be tolerated. Maximum emphasis, therefore, must be placed upon supply logistics--principally aerial delivery--which will leave the soldier as little burdened as possible with carrying his own supplies. It must be anticipated also that with high mobility, combat groups frequently will be cut off from the usual channels of supply and will be forced to fight and live on what they have with them or can be supplied by aerial delivery.

Decisions will have to be made on-the-spot on the amount and type of materiel that should be delivered. Unlimited aerial supply of everything that might be desirable both in kind and quantity, including luxury items, will be out of the questions. In fact, frequently it may reach the critical point where the decision will have to be made whether to call for beans or bullets. The commander must be provided with the essential information upon which to base a rational choice, if a rational choice is to be made. If only 10 or 20 or even 50 pounds of materiel can be furnished each man per day by aerial delivery, what items should make up the load? What is the amount and the relative proportion of the items that will best maintain the operational effectiveness of the soldier for a few days, a week, a month, or even longer?

Among the more basic needs of the combat soldier are included food, water, clothing, equipment, weapons, ammunition, fuel, transportation, communications. Of these basic needs, food and water are daily indispensables regardless of where the soldier is or what he is doing--these must be furnished under all situations. Each day we use between 5 and 10 pounds of food depending on many factors such as physical activity, body size, state of fatigue, emotional state, environmental conditions, acceptability of the food, etc. Daily drinking water intake, including beverage and water in food, ranges from about 5 pounds for relatively inactive conditions in a mild climate to 25 pounds or more in hot desert or tropic conditions or with severe physical activity. On the average then we, on a free intake basis, consume between 10 and 35 pounds of food and water per day in order to keep in energy and water balance.

What happens to the soldier if these optimal or maximal amounts of food and water cannot be furnished? What is the least amount of food and water that must be furnished to maintain the individual effective for reasonable periods of time? To what extent and for how long is it possible to choose bullets instead of beans when supply capability is limited?

Some data are now available which provide clues on what can be expected of men when either food or water or both are restricted. To provide answers to the questions, several groups of soldiers were placed on a controlled routine of hard physical work and on food intakes ranging from 3600 calories per day to no food with water intakes ranging from all they desired to only one quart per day. Measurements were made on the ability of the men to perform various types of tests involving physical work. All the studies were conducted in a temperature controlled room held at $75 \pm 5^{o}F$. Extremes of heat and cold and the emotional stresses of combat would no doubt have altered the results somewhat.

The combinations of restricted food and water studied were: (1) 3600 calories, water not restricted; (2) 1600 calories, water not restricted for 6 months; (3) 1000 calories, water not restricted for 21 days; (4) 550 calories, water not restricted for 14 days; (5) no food, water not restricted for 4 days; (6) 1000 calories, 2 qts. water for 12 days; (7) 1000 calories, 1 quart water for 6 days.

Measurements of physiological and psychological responses showed surprising resistance to loss of capabilities when food intake

was reduced to as low as 550 calories per day. Water restriction was more serious. But even with calories restricted to 1000 per day and water intake limited to 1 quart per day, ability to perform physical work was maintained at normal levels for about 5 to 6 days. When 2 quarts of water were furnished along with 1000 calories per day, performance capability was normal for about two weeks.

If the individual has no food to eat and yet must do physical work, deterioration progresses rapidly. After the first day, the soldier will not be capable of effectively carrying out his duties. However, an inactive man can survive complete lack of food for a month or more. Another interesting phenomenon is the apparent ability of man to adapt to short periods of starvation so that the effects of going without food for a few days become less severe with each successive fast experienced.

In all the combinations studied, except the control (combination 1), there was a loss in body weight. When percent loss in body weight is correlated with percent change in ability to work, the following generalizations appear:

- 3.5% loss in body weight = 95% normal ability;
- 7.5% loss in body weight = 90% normal ability;
- 10% loss in body weight = 85% normal ability;
- 15% loss in body weight = 70% normal ability.

The rate at which the loss in body weight occurs is also important and will change the general relationships; the more rapid the weight loss, the greater will be the deterioration. However, a surprisingly small amount of food (only 10-15% of a normal ration) is sufficient to prevent serious loss of operational capabilities for several days.*

Summary:

In order to keep the soldier effective, food and water must be furnished at least in small amounts every day. However, the minimal amount that is required may be considerably less, for rather long periods, than is generally thought to be needed. Over a period of a few days food intake can be drastically reduced without seriously interfering with the soldier's ability to accomplish physical work. Mobility of the soldier can be increased when necessary by limiting the total food the soldier must carry or that must be supplied. This should give the field commander a greater degree of flexibility in deciding the item make-up of critical load weight and space.

*The research was conducted as a Joint program between AMS and QMC.

2. "SMALL UNIT CLOTHING TARIFFS"

by
Dr. Russell W. Newman
Anthropology Branch, Environmental Protection Research Division
Quartermaster Research and Engineering Command

Introduction

As the U. S. Army adjusts its organization, weapons, and procedures to the era of atomic warfare, new logistical techniques and concepts are becoming necessary. The accent on mobility extends from the individual soldier through the tactical units and into the logistical organizations. In terms of the logistical elements, we may expect at least three results of this process: reduction in service personnel, curtailment of previous functions, and a shift of some functions to the combat elements. This latter resultant process poses problems which will be treated here.

The mass issuance of sized items of clothing and equipment to forward combat elements is our specific problem for the moment. Mass issuances of what might be termed "emergency replacement items" should characterize warfare where CBR in some form will necessitate unit replacement of contaminated or partially destroyed clothing. Increased air mobility should greatly intensify the normal exchange of clothing to meet seasonal requirements. It is believed that such deviations from the traditional clothing exchange system will occur with sufficient frequency and urgency in tomorrow's Army to require new field supply concepts and techniques. The root of the trouble is a human factor - that men come in assorted sizes and shapes, the exact distribution of which cannot be predicted except for very large groups. The number of items of any one size expressed as a fraction of the total items issued is called the "tariff" for that size. Thus, for every thousand or ten thousand shoes issued a certain proportion will be 9 D's; Supply Bulletin 10-S23, 16 December 1955, lists this figure as 5250 per 100,000 low-quarter oxfords, based on "worldwide issue experience." When sufficient quantities are stocked at a large issuing installation (for

example, 90 days of supply), local imperfections in the size tariff can be adjusted on subsequent reorders. But, how can we operate on this basis in a truly mobile army for what are essentially one-time issuances and when stockages must be kept at an absolute minimum? And, how can we accomplish effective issuances in small combat groups (battle-groups and smaller) where there can be no reasonable expectation of agreement with worldwide issue tariffs? It should not be inferred that such a problem is new to the Army, for it is not; but it should be a more serious problem in mobile warfare.

Even with the sketchy background given above it should be possible to consider various solutions to this problem, in ascending order of their probable utility. First, we could obviate the problem entirely by eliminating all sizes in clothing and equipment. This is patently impossible in the foreseeable future for all items and need not be discussed further. (A partial solution of reduction in sizes in some items is possible and will be illustrated later in this paper.) Second, we could minimize the problem by filling units with selected sizes of men. For example, we could have one unit consisting exclusively of small men, another of large men, etc. The ultimate cost of such a method in duplicated training and inability to freely utilize individual capabilities would be tremendous and far greater than any possible saving in ease of logistical support. Third, we conceivably could have each unit summate the individual requirements of its members and order only exactly what was required for those personnel. This solution does not appear very realistic since it is based on the assumption that someone knows exactly who is in the unit, what is required, and has the facilities to rapidly summate this information. Furthermore, it is assumed that the time interval between the collation of the size information and the issuance of the items will be so short that no casualties, replacements, or transfers will have occured within the unit. While such a system might be theoretically possible, its feasibility in the foreseeable future is not good. Fourth, we could use the present system and simply order an excess to take care of deviations from the worldwide tariff, returning the unissued stock afterwards. The critical problem here is to know just how many of each item to order--certainly enough to cover requirements, but no more than that--to minimize the drain on the theater stockpile and the wasteful, retrograde movement of unused items. The more decentralized our basis of issue becomes, the more critical will be the selection of the most appropriate number of items in the correct sizes.

This is the essence of our paper--to present some of the techniques and results of the first known attempt to calculate realistic tariffs for small units of men. Its rationale for being introduced in a Human Factors conference is that only through long-term military support of one of the disciplines concerned with human factors could appropriate data for this effort be amassed and available.

Methodology

A number of working hypotheses had to be used in this study without specific verification. It is hoped that these hypotheses will be made clear to the reader, at least in so far as they are apparent to the writer. The first hypothesis was that we could construct from our anthropometric files imaginary combat units which would have sufficient reliability for our purposes. The files from which we drew our material consist of records of approximately 100,000 soldiers, measured in 1946, who came from all sections of the country. Our only method of bringing the series up to date was to extract from it an age and race weighted sample of 10,000 cards of men who correspond to the age and racial composition of present-day Army personnel. This series was measured on soldiers being separated at the end of World War II; the bodily proportions of these men are probably closer to a war-time Army than we could gather today. The second hypothesis was that we could assign clothing sizes to each man accurately from his body measurements. We know that this will not always work but, if the errors are random rather than systematic, they should balance or cancel out in the long run. Therefore, we extracted the pertinent body measurements, assigned clothing sizes, and made up a special 10,000-man sample of IBM cards. These cards were then divided randomly into one hundred samples of 100 men each--the randomness was achieved by using the final digits of the man's series number in our larger sample. From then on it was simple to tabulate the size tariff for any item on our card on each of the 100-man samples. We also wished to accumulate size tariffs on one hundred samples of 500 men each, and we constituted each of these samples by combining five 100-man samples selected from a table of random numbers. Finally, we made up ten 1000-man samples by combining ten of the 100-man samples; also selected randomly (actually, we discarded any 500 or 1000-man sample that contained a duplication of any 100-man sample, so the result was not truly random). In that portion of the study reported here we used as our critical figures the greatest occurence in any size category in any sample within the 100-, 500-, and 1000-man series. While each sample in the 100-man series, for example,

added up to only 100 garments, the total of the highest frequencies for headgear by size equalled 144 garments. Thus, the worst conceivable combinations (from our data) would need 144 caps on hand to fit any hundred men.

Results

It is obvious from the foregoing that we ended up with one hundred size tariffs for each "unit size" (100, 500, or 1000 men) for each of the items processed. We took eight categories of sized items of clothing as being representative of combat clothing and equipment. This gives a total of 2400 size tariffs which will not be reproduced here. In fact, this paper will present no size tariffs, only the sum totals which represent the number of garments. The detailed material will be presented elsewhere in a more technical report.

TABLE I: SMALL UNIT CLOTHING TARIFFS
ALL MEN FITTED WITH PREDICTED SIZES

Item	No. Sizes	100-Man Units	500-Man Units	1000-Man Units
Headgear	7	144 (44%)	588 (18%)	1124 (12%)
Handwear	5	128 (28%)	573 (15%)	1095 (10%)
Sockgear	5	147 (47%)	596 (19%)	1106 (11%)
Upper Body, Girth Sizes Only	5	142 (42%)	578 (16%)	1111 (11%)
Lower Body, Girth Sizes Only	5	140 (40%)	584 (17%)	1095 (10%)
Upper Body, Girth & Length Sizes	11	174 (74%)	641 (28%)	1186 (19%)
Lower Body, Girth & Length Sizes	9	162 (62%)	623 (25%)	1160 (16%)
Footwear	37	248 (148%)	763 (53%)	1339 (34%)

The categories of items, the numbers of sizes analyzed, the total number of items required for each sized unit, and the percentage of overage (number of garments in excess of number of men) are listed in Table I. Some explanation of the item category is required. For headgear we used the familiar cotton, field cap, which is our principal item of combat headgear when the helmet is not worn or cold-weather protection is required under the helmet. For handwear we used the sizing system of the leather glove, shell, our principal work glove. For sockgear we used the cushion-sole sock with which you are all familiar. The next four items in Table I are really indicative of several garments which integrate together in combat clothing. Upper body, girth size only, represents such items as the winter undershirt, the field shirt, the parka and others which are sized as small, medium, large, etc. The lower body, girth size only, represents comparable garments such as winter underwear drawers and the liners for cold weather trousers. The two items listed as upper and lower body, girth and length sizes, refer to garments such as the coat, man's, field (formerly the field jacket) and trousers which are sized in both small, medium, large and short, regular, long. For footwear we arbitrarily used a reduced sizing system of only whole lengths (7, 8, 9, 10, etc.) and every other width. Combat footwear is presently not issued in this way, but it seemed the only feasible way to achieve anything approaching a reasonable overage. We have used a reduced number of shoe widths in rubber combat footwear for some time; also there is evidence from a recent study that every other shoe length may be acceptable.

It is obvious that the tariff totals given in Table I are not the highest that might be encountered if this system were used for hundreds and thousands of units. On the other hand, we have gone far beyond the worst sample in the one hundred samples analyzed when we selected all of the maximum size frequencies. There doesn't seem to be any statistic designed to express the confidence with which our tariffs can be viewed, but it is my personal opinion that we have subsumed at least 95 percent of the possible combinations.

For the reader's convenience, the total garments required per 100, 500, and 1000 men have been charted graphically in Figure 1. It will be apparent from the eye-drawn curves in this figure that interpolation to any number of men between 100 and 1000 is possible for

any item. This figure is not intended as a practical working tool since this would require separate size graphs for each item. However, such graphs are perfectly feasible. It might be possible to extrapolate to 1100 or 1200 men with little loss of accuracy, but extrapolation to less than 100 men might be unwise.

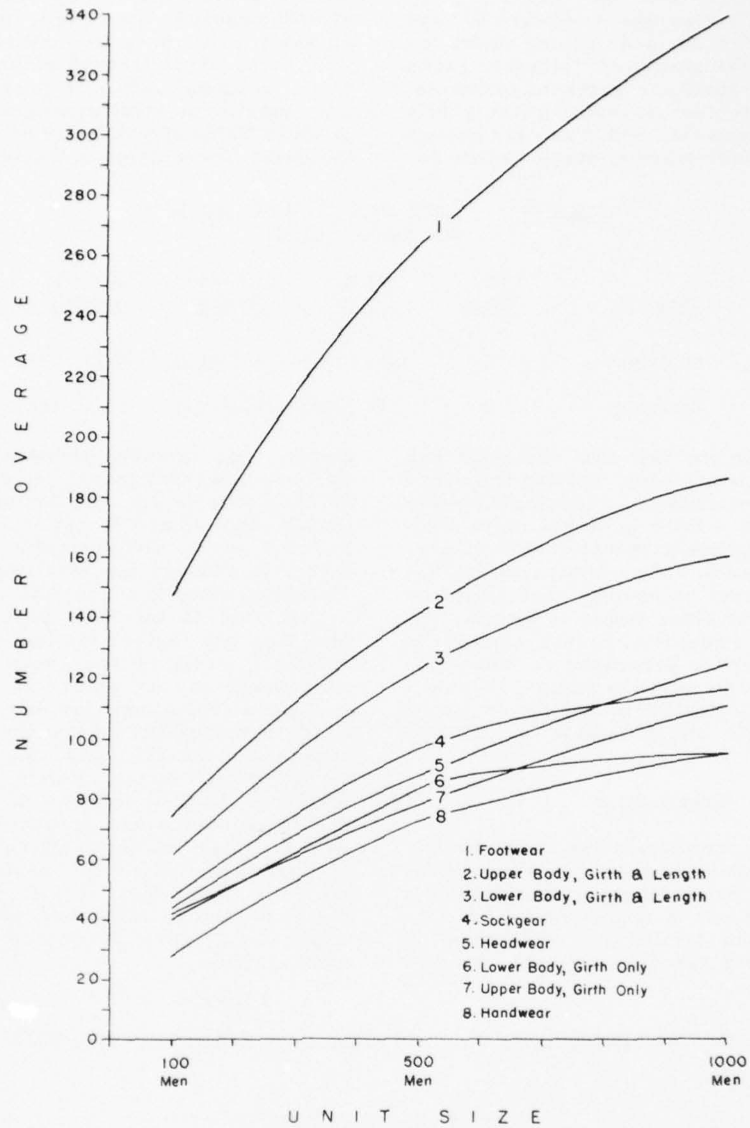


Figure I: Garment Overage for Small Unit Tariffs

Reduction in Number of Sizes

In the introduction, reduction in the number of sizes required to adequately cover the military population was mentioned as a possible solution of small unit tariffs. This would not be simple to achieve since, for almost a decade, there has been a continuing QMC R&E effort to reduce sizes or make one size cover a larger segment of the population.

For example, we now furnish combat body clothing in a four-inch chest grade which means one-fourth the number of sizes used in men's commercial suits or in our military semi-dress clothing (Army green uniform). We furnish headgear in only one-half the

sizes carried in commercial stores. Furthermore, we are convinced that we cannot sacrifice design and fit to the point where the clothing and equipment constitute an unreasonable decrement to the efficiency of the individual soldier. The only technological progress in this area which appears to have real promise for the near future is the incorporation of the so-called "stretch" yarns as integral or auxiliary parts of garments.

There are two combat clothing items utilizing stretch material which are far enough along in the developmental stage so that recalculations on small unit tariffs can be made. These are stretch-type cushion-sole socks and the cotton field cap. The socks are a military variation of stretch-type commercial socks with wool in contact with the foot, and the caps incorporate one or more stretch panels in the crown. Both items presumably can cover the military population with three sizes instead of the five or seven sizes required with our present garments. The maximum total numbers required are given in Table II which can be compared with the same items listed in Table I.

TABLE II: SAMLL UNIT CLOTHING TARIFFS FOR REDUCED SIZES

Item	No. Sizes	100-Man Units	500-Man Units	1000-Man Units
Headgear	3	126 (26%)	553 (11%)	1075 (8%)
Sockgear	3	120 (20%)	542 (8%)	1055 (6%)

It will be seen that the size reduction has resulted in approximately halving the overage for 100-man units and reducing the overage by at least a third in larger units. This should be a significant reduction of the logistical requirements, and probably indicative of the general level of savings that might be accomplished in other items if similar redesign becomes possible. In fact, even if the small group tariffs generated by this study are never used in wartime supply, they may prove a useful device by which to gauge progress in the simplification of clothing sizes.

Conclusions

This short presentation has avoided many of the complexities of supplying sized items to small units. Some of the thorniest problems will fall in the areas of packaging or containerizing such tariffs and implementing appropriate field issue procedures. For example, our present system of packaging cushion-sole sockgear is to place 420 pairs of each size in its own factory carton. Although this may be the cheapest way to package socks, and amenable to large-scale issue, it exceeds the size requirements for 1000-man units in every size and by as much as ten-fold in the least popular sizes. We feel that one logical implementation of this research would be the creation of a certain percentage of our stocks in "unit" packs, ready for supply emergencies. What we have tried to emphasize is that there are readily available research data, such as our anthropometric series, which can pay large dividends in the solution of human factor problems. Since our approach started with data which are particularly suitable for EAM manipulation, we can and hope to modify our analyses in the light of further research on the reduction of sizes and possibly on field trials of the supply processes in tomorrow's mobile army.

3. "ENVIRONMENTAL CRITERIA FOR EQUIPMENT DESIGN"

by
Dr. William B. Brierly
Quartermaster Research and Engineering Command

In order to attain the capability of conducting military operations in any world area, the Department of the Army policy is:

a. to insure that all combat and combat support materiel is capable of satisfactory performance at all times under extreme, as well as basic operating conditions.

b. to select and utilize environmental testing sites in order to test equipment, supplies and techniques under all types of environmental conditions for which each was intended.

c. to analyze the performance capability of Army equipment and materiel prior to or concurrent with the commitment

of Army forces in any area of the world in order to insure selection of the most suitable standard and special equipment and to bring to light any limitations in performance caused by environmental stresses.

Should these policies be attained there would be no difficulty in operating anywhere in the world. Under basic operating conditions (those usually met in the temperate areas) most of these policies have been applied successfully. In areas of extreme operating conditions, whether hot or cold, wet or dry, mountainous or low-lying, the same degree of success has not been attained.

Since the world is composed of a great many environments and since much of our equipment or materiel will not be used in areas of extreme operating conditions one wonders whether the same rigid rules should apply or whether they should not be limited to "critical" equipment only.

In this respect, the increasing complexity of military equipment has been generally accompanied by an increase in sensitivity to local environmental conditions. This presents a very grave problem since modern war may require critical equipment to operate across many environmental areas within a very short time.

The Staff planner and the field commander must have reliable estimates for evaluating performance to be expected of his equipment and materiel, the circumstances likely to bring about significant deterioration in that performance, the particular failures likely to occur, and the remedial measures necessary.

The new Pentana and similar doctrines, the speed with which critical situations can arise, and the great variety of tactical, strategic and operational environments possible, make it most important that an all-out effort be made to implement the D/A policy statements made above in Paragraph 1.

Before this can be accomplished our present philosophy will have to be more critically examined. The environmental factors must be evaluated on more realistic terms, only criteria that have known applications must be used, tests must be designed so that they lend themselves to statistical analysis when possible, more rigid standards must be established and strictly adhered to in order that a more valid basis for comparison between tests within the Military Departments can be made, and finally there must be an effective relationship established between stresses as they occur in nature and those simulated in the laboratory. Should this philosophy be carried out operational capabilities of the Army would include the world.

Now what is being done to implement this philosophy in the Department of Defense?

Under the auspices of the OASD (S&L) an Environmental Working Group, composed of operating personnel from each of the three Military Departments, have been meeting on a somewhat regular basis since 27 August 1957 with the objective in mind of preparing an Engineering Plan for Standardization within the Environmental Field. An initial plan was prepared and is now being implemented by various Subworking Groups; Policy statements and Standardization tasks have been completed. It is hoped that the plan will soon be ready for distribution and comment before implementation.

The plan envisions a blending of short and long range research and standardization projects, which will eventually place our whole program on a valid scientific base. The critical base point, like any other scientific program, is to get the problem defined. This means that we must know what process of deterioration is taking place or causing failure or limiting performance, and what elements of the natural environment are influencing and are exerting the stress and how the stress is exerted. Once this has been determined the criteria used for designing tests can be established and the frequency, duration and a real distribution can be plotted for regions to determine what military risk factor will be acceptable.

It must be understood, however, that the military risk factor is not a constant but will vary from operation to operation as well as from area to area. But only by knowing the environment and equipment performance in that environment will this flexibility of military risk have any substance.

One impact of this philosophy may well result in placing stringent demands upon environmental analysts as well as upon testing personnel and may necessitate extending the observed spectrum of environmental factors beyond present capabilities.

Just as the proof of the pudding is in the eating, so the climax must be field tests simulating wartime task-force operations. This will point up the weaknesses in both human engineering and equipment capabilities in an extreme environment.

Although we can design equipment that will work in most areas of the world, the end result will be limits imposed by the capability of man to live, fight and operate equipment under adverse conditions.

The epitome of this philosophy is knowledge of the performance capabilities of both man and equipment for any season of the year in any part of the world.

VII. U.S. ARMY TRANSPORTATION CORPS PRESENTATION

"GROUND MOBILITY AND TRANSPORTATION"

by
Dr. John W. Bailey
Transportation Research and Engineering Command

Control of the land is still a prerequisite to military success. Getting control of the land usually involves some sort of transportation--either by land, by water or by air.

In The Second World War, ground mobility was far from satisfactory even though measured under the most favorable conditions. This situation is still a bit fuzzy, especially when we consider the impact of nuclear weapons upon the peace and security of the world. Ground mobility--particularly cross-country mobility--is now more essential than ever before.

The transportation equipment designer is faced with the ever-present problem of having to combine as many optimums as possible: mobility, range, speed and other desirable factors must be joined insofar as it is compatible with economy, dependability, ruggedness, protection, simplicity, lightness and compactness. The major difficulty facing the designer, is, I believe, the lack of available, prescriptive, comprehensive information on the satisfactory relationships between a land vehicle's "form" and the environment in which it operates, particularly in cross-country or off-road operations. Fundamental questions are just beginning to be answered.

This slowness is not unjustified. We all know most automotive engineering know-how and experience have grown from the observation and tabulation of the machine in what is a rather simple environment: a hard surface or roadway. Industrial efforts have been aimed at refinement and improvement of mechanical and technological details of the machine by commercial application. The Services' requirements have suffered as a result. We in the Armed Services assume that the highway vehicle has reached something final. Improvement of its mobility would seem to depend upon highway improvement or extension rather than a further change in the vehicle itself. There is little hope, consequently, that road transport technology will directly foster the development of cross-country vehicles.

We recognize, of course, that the requirements of industry and commerce in ground mobility differ from military ground mobility requirements. Speaking broadly, industry and commerce are more concerned with operations in standard conditions. Nevertheless, civilian cross-country vehicular requirements developments have been increasing. Such developments, I may say in passing, are closely watched for what benefit may accrue to the Military.

Army vehicles, on the other hand, are not subject to set environment conditions. Mobility of the armies is not restricted by an unwillingness to fight off the beaten track. Mobility is, none the less, restricted by serious terrain obstacles and by the "state of the art". There exists in the world today a state of widespread unrest and a requirement for fluid dispersion and great mobility in nuclear warfare. These two factors call for the anticipation and planning of cross-country operation in various regions....arctic, desert, prairie, tropic. In fact, all landscapes must be considered.

The inadequacy of existing knowledge has been recognized and important steps have been, and are being, taken to correct the deficiency....by Government, by Industry, and by our centers of higher learning. The task of furnishing the required knowledge is a project for many individuals and agencies rather than the project of a single group or organization. It is gratifying to see the plurality of interest and work on those problems. Without such widespread interest and work, land mobility will not emerge in that rational con-joining of environment and machine which is so necessary in the atomic age. The present meeting is certainly a step toward this emergence.

In the remaining time, I should like to discuss some current and projected military transportation developments. Some are clearly interim measures--but steps toward the ultimate goals.

Transportation Developments

A current amphibious development is the BARC. The BARC is a large wheeled, ramped amphibian, designed to transport vehicles--tanks, mobile cranes--and other cargo up to 60 tons from ship to shore and over the beach. It provides the Army with a new dimension in mobility and heavy-lift capability for amphibious operations. A limited number of first-run production models are presently undergoing troop tests.

Complementing development of the BARC are the 5-ton and 15-ton amphibians, currently in the design stage. The 5-ton amphibian will have drop sides for side loading and unloading and will be able to negotiate rough terrain adjacent to the beaches. The 15-ton amphibian will provide ramp loading or unloading, and be equally capable of beach and rough terrain movement. Together with the BARC, they comprise a new family of amphibians, supporting battlefield mobility requirements of the ground forces.

With the Quartermaster Corps, we are developing two Rough Terrain Forklifts: a 6,000-lb model, and a 10,500-lb lift model.

The Rough Terrain Forklifts are designed to transfer unitized, containerized (including the CONEX Container), and bulk cargo in and about terminal areas, and from landing craft to other vehicles for movement to interchange and forward depots in the Army area. They are equipped with 4-wheel steering and high flotation tires which enable them to handle material on sand, deep snow, and other terrain which immobilizes conventional vehicles. They combine with the need for wide dispersion and deployment of supplies, to provide a high degree of mobility in the supply and logistical services in support of the combat forces.

A teammate or cousin to the Rough Terrain Forklifts, the Rough Terrain Crane, is currently in the fabrication stage of development. It will be capable of operating in surf, shore, snow, and other difficult terrain, and will provide us with a mobile lift capability up to 10 tons. With Rough Terrain Forklifts, it represents another means to support mobility of the combat forces.

Still another means to reduce drag on the combat forces in a nuclear climate of dispersion and fluidity, and provide us with off-road flexibility in the movement of cargo, is the Overland Conveyor System. It is designed to move pallet loads, containers, and other cargo cross-country, with special affinity for difficult terrain. The Overland Conveyor System is sectionalized, airtransportable, and can be quickly assembled. It reduces or does away with truckhauls, and provides a more continuous means of transport than is possible with individual transport units. The Overland Conveyor will be on display at the Buna Hill demonstration. A more advanced model is currently under development.

Spotlighting the growing strategic importance of the Arctic regions and the need for rapid cross-country mobility in such regions, is the Logistical Cargo Carrier, Mark I. The Mark I has a payload of 30 to 45 tons at speeds of 10 to 20 miles per hour over Arctic terrain. These speeds may seem rather low, but they are appreciably greater than the two and three miles per hour we have been obtaining from tractortrains.

The Logistical Cargo Carrier, Mark I, is made up of a lead vehicle and three cargo trailers. The lead vehicle houses the control station, communication station, crew quarters, and the power plant and fuel tanks. The power plant is a 600-hp diesel engine driving three generators. The main generator provides power to motors in each of the sixteen wheels. The wheels measure 10 feet in diameter and 4 feet in width, and in combination with low pressure put down a large tread area. The wheels track automatically behind the wheels of the lead vehicle. Overall length of the Mark I is 174 feet. The range is 200 miles, admittedly not what we would like it to be.

A successor to the Mark I is already planned, the Mark II. It will be a 12-car conventionally powered train, providing greater tonnage hauling capability, among other advantages. This vehicle will allow test of a 12-car concept pending availability of a nuclear-powered car, a development which promises to be something of a technological break-through in off-road mobility. Utilizing a nuclear reactor for an off-road train such as the Logistical Cargo Carrier, has been determined to be feasible. It would be capable of hauling large tonnages, rapidly, cross-country, over arctic, desert, prairie, and other terrain in support of tomorrow's army. The army has a proposal up to the Department of Defense now to let us go ahead with its development. Its outstanding feature, of course, would be its ability to operate for long periods of time without refueling, and the by-products: increased range and payload. The reactor would be located at the rear of the train to minimize crew exposure to radiation.

Another area of off-road or cross-country mobility capability which the Army Transportation Corps must anticipate and plan for is in marshy terrain. Based on a recent study, we are proposing for development a marshy terrain vehicle. It will be of the floater type, be bellyless, and be long and narrow consistent with stability requirements. It will have high obstacle-crossing ability, and carry a minimum net payload of five tons. Such a vehicle will be also suitable for operation in tundra and muskeg country.... found over wide areas in Alaska, Canada, and the Soviet Union.

Another development is the Rolling Fluid Transporter, which is designed for road and off-road fuel transport and has just finished cross-country deep snow mobility tests in Northern Michigan, at Houghton. Each transporter is capable of carrying 500 gallons of fuel, with a discharge rate of 50 gallons per minute, and is paired with a rig to provide 1000-gallon towing units. Each unit compris-

ing two transporters and towing rig weighs 2300-lbs empty. Overall width is 96 inches, so that it can be towed on roads and highways without running into difficulty about clearance. In tests so far conducted, five units have been towed up to 20 miles per hour. The Transporter is still experimental, but promises to be a very practical means of fuel transport, particularly in off-road support of combat operations as you will observe this afternoon at Buna Hill. It eliminates the need for special purpose vehicles--a constant objective in the development of new equipment--such as the 5000 gallon tanker which has little, if any, off-road mobility. Additionally, it is easily airtransportable, and can be expeditiously dropped in conenvient units to widely dispersed elements of the combat team.

In the realm of more conventional mortor transport developments, namely, on-road transport, is the new XM 282, 8x8, 5-ton truck. This is an Ordnance Corps development, strictly speaking. The Transportation Corps, however, has been testing the XM 282 with the objective of determining the feasibility of replacing the $2\frac{1}{2}$-ton 6x6 truck with the 282. Such substitution was found to be feasible with certain changes, such as incorporation of drop sides and a tilt type cab.

Conclusion

I have tried to indicate that the emphasis in military motor transport technology is on cross-country mobility. The opening thrust into this entirely new field of endeavor has been made. We can expect important developments to follow which, I believe, will ultimately solve the problem....or certainly bring us closer to true mobility. Some transportation developments I've described to you closely parallel requirements established under the GOER concept. Mobility can, of course, be achieved in other ways. The use of stronger, lighter metals, better engine performance and fuel economy, longer parts life, all contribute toward mobility in their own way. Such efforts will be continued.

Finally we can augment ground mobility with other forms of locomotion. I am thinking now mainly of air vehicles. Aircraft alone no doubt will provide the ideal answer for many tasks in the field within the limits of their capacity and availability. Allied with ground support elements in the form of cross country vehicles, in which one lends a helping hand to the other--using, for example, helicopters such as the new H-37 to cross rivers and canyons--mobility on the battlefield is brought one step closer to something final.

VIII. U.S. ARMY CORPS OF ENGINEERS PRESENTATIONS

1. "HUMAN ENGINEERING IN CORPS OF ENGINEER EQUIPMENT DESIGN"

by
Mr. Turner G. Timberlake
U.S. Army Engineer Research and Development Laboratory
Ft. Belvoir, Va.

One of the most important aspects to be considered in equipment design regardless of the configuration, size, operation, or application of the item, is that it must be capable of being operated and serviced by man, the variable factor upon which human engineering is based. It follows, therefore, that human factors engineering, or simply human engineering, may be defined as the application of data and principles about human performance to the planning, design and development of equipment, components and systems.

The basic objectives are to improve and maximize the field performance and reliability of man machine systems, particularly with respect to human factors. These include problems involving speed and accuracy of operation, operational reliability, minimization of operator training and skill requirements, safety and operation under stress. It is evident that the factors just mentioned play an important role in the military when one considers that military operations must be planned regardless of the time element, terrain or weather conditions. These factors are always aggrevated by rapid expansion of the armed forces to meet emergencies as they occur. The equipment assigned to troops, therefore, must be simple to operate and maintain, as well as require a minimum training time to obtain maximum performance.

We in the Mechanical Engineering Department of the Engineer Research and Development Laboratories have evaluated human factors in many different ways. Unfortunately we have not initiated a human engineering program as such. However, in an undetected way we have considered the human factor in all of our equipment design. Most of our efforts to date have been of a missionary nature since a large portion of our equipment is basically commercially available off-the-shelf items. We have, however, conducted extensive Ease of Maintenance studies on a number of commercial type items including a crawler tractor dozer, rubber tired motor grader, an engine generator and other high population items in our supply system. Our tests proved very successful. To cite an example, we reduced the time limit for removal of a damaged engine from a motor grader by 85%.

At our Laboratories, perhaps the greatest emphasis on human engineering has been placed on equipment designed for Arctic operation. Human Engineering science in Arctic operation is quite evident and is a necessity for survival. The personnel must be protected against the bitter cold. This, naturally, is accomplished by providing adequate clothing. Because of the extreme low temperatures this clothing becomes bulky. Consequently operations which are normal in the temperate zone become major tasks in the Arctic. The low temperature work was centered mostly in providing adequate protection to the personnel by furnishing warm cabin enclosures with good visibility, quick escape hatches to provide further protection when operating over cravass areas or ice, or other hazardous areas. If the operator can be kept reasonably comfortable he is capable of performing his mission. We were compelled to consider the human factor in equipment scheduled for the far north; more so than in commercially available equipment for use in the temperate zone. Private industry was not engaged in furnishing equipment for operation in extreme low temperatures and, as such, had not given much thought to this problem. On commercially available items, however, we have relied much on private industry to furnish the human engineering considerations required in the basic design.

Through the Society of Automotive Engineers, these Laboratories have initiated two basic programs which may be considered major steps in the human engineering field. SAE Sub-Committee XV on "Winterization" is one, and SAE Sub-Committee XVI on "Ease of Maintenance" is the other. Looking from a broad aspect, however, all the work being conducted in conjunction with the Society of Automotive Engineers through their Sub-Committees is, in one form or another, related to this new human engineering science. As mentioned previously human engineering is not limited to any one specific item but may involve a complete system or technique whereby many individuals and/or end items are concerned.

Early in 1949 the Engineer Laboratories initiated a program to develop a family of air transportable construction equipment for use

in assault type operations. In view of the serious restrictions imposed on this group of equipment relative to height, width and length, much consideration was given to human engineering even though at that time it was not referred to by that name. The airborne program, in essence, resulted in modified commercial equipment which by no means simplified the logistical problem. With this background as a basis to start anew, a completely new approach to the combat engineer and airborne mission was envisioned.

This system has centered around the development of ballastable all-purpose equipment to provide one item with many capabilities. In view of the versatility of these items it became apparent that serious consideration would have to be given to the human engineering aspects to provide an efficient unit capable of many tasks. The two basic items considered in this program are the Ballastable All-Purpose Tractor (Fig. 1) and the All-Purpose Ballastable Crawler (Fig. 2) hereafter referred to as the BAT and ABC Tractors respectively.

Heretofore, equipment employed by the Corps of Engineers to meet tactical requirements and furnished by the construction equipment industry have been off-the-shelf items in some cases modified to meet specific requirement. At present those items are being procured in quantity by the use of performance type specifications on a competitive basis. This practice is necessary to meet the unusual military quantity requirement and to establish a realistic mobilization base.

It must be remembered, however, that all the items purchased are designed for specialized operations, with the result that the Corps of Engineers has accumulated a tremendous variety of equipment. This variety of equipment is further complicated by numerous makes and models. The possible magnitude of the support problems related to operation, maintenance and repair parts, conducted along the current practices is very vividly shown in Table 1.

At one glance this tabulation shows that the 13 major categories of equipment now used in commercial and military construction could involve as many as 584 different makes, constituting 2,249 models. From a logistical support standpoint these figures are astronomical. Future military operations as envisioned today, keeping the human factor in mind, cannot support such multitudes of equipments in the field and the present system is doomed to failure when considering self sustaining highly mobile forces.

TABLE I

Current Make and Model Complex of Commercial "Off The Shelf" Construction Equipment

Equipment Category	Number of Makes	Number of Models	Military Variations
Tractors	15	67	562
Road Graders	13	33	38
Pumps	59	182	182
Cranes and Crane Shovels	54	215	267
Generators	110	490	539
Attachments	108	671	1047
Rollers	30	66	74
Asphalt Equipment	45	85	92
Road Clearing and Cleaning Equipment	45	87	99
Rock Crushing and Processing Equipment	27	53	63
Concrete Equipment	29	58	82
Compressors	35	197	250
Scrapers	14	45	47

One way to simplify the logistical load, as well as improve mobility and construction capabilities to a degree, is to develop multi-purpose military specials. These military specials must be capable of performing the basic tactical tasks of present airborne and combat equipment. Developing items of this sort, however, present a multitude of human engineering problems. The item must be so designed that it will be capable of performing several tasks, such as clearing, dozing, grading, scraping, towing, hauling, and many others, with a definite degree of accuracy and performance. The item must also be so designed that the operator, regardless of the operation intended at the time, can perform it efficiently. To cite examples, dozing, grading and scraping essentially may be similar operations as far as the end result is concerned; however, manipulation of the equipment is somewhat different. These manipulations must be incorporated in the item to provide a maximum degree of accuracy with the average operator. These are the problems we are considering in the

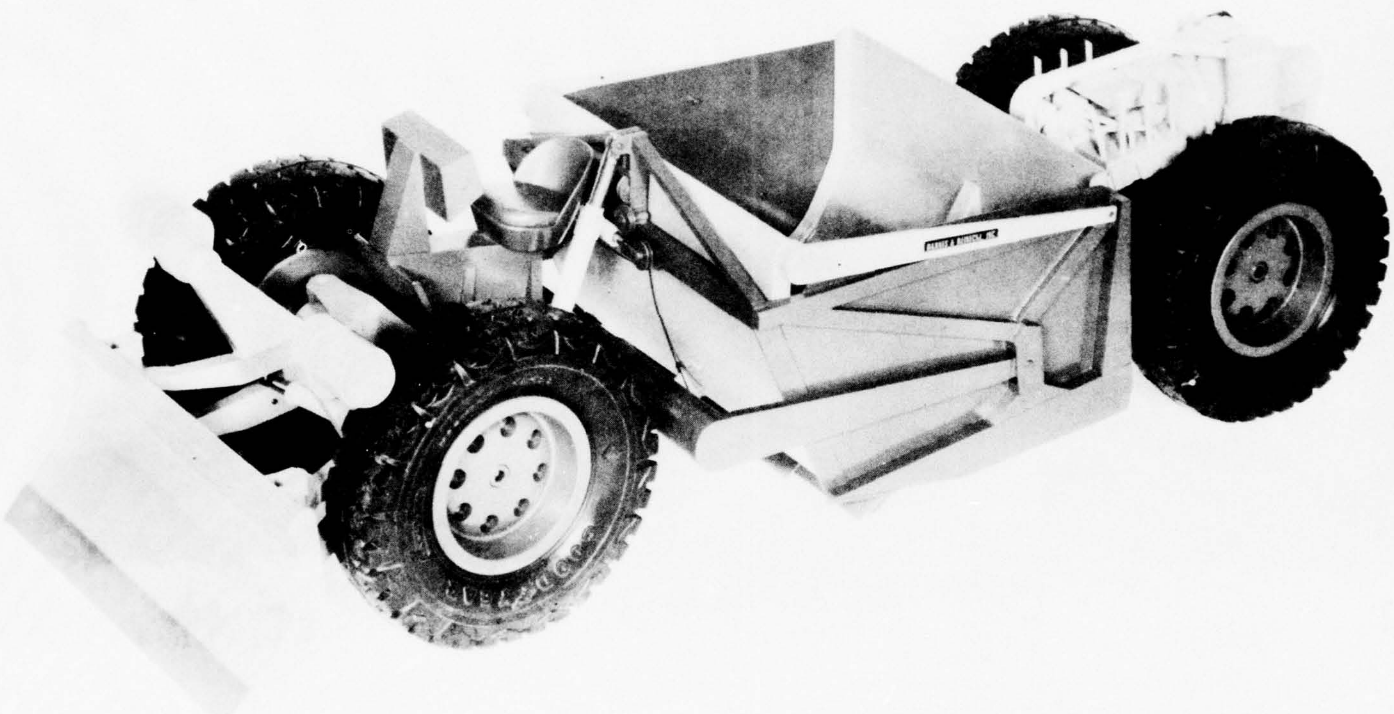


Figure 1.--The Ballastable All-purpose Tractor (BAT)

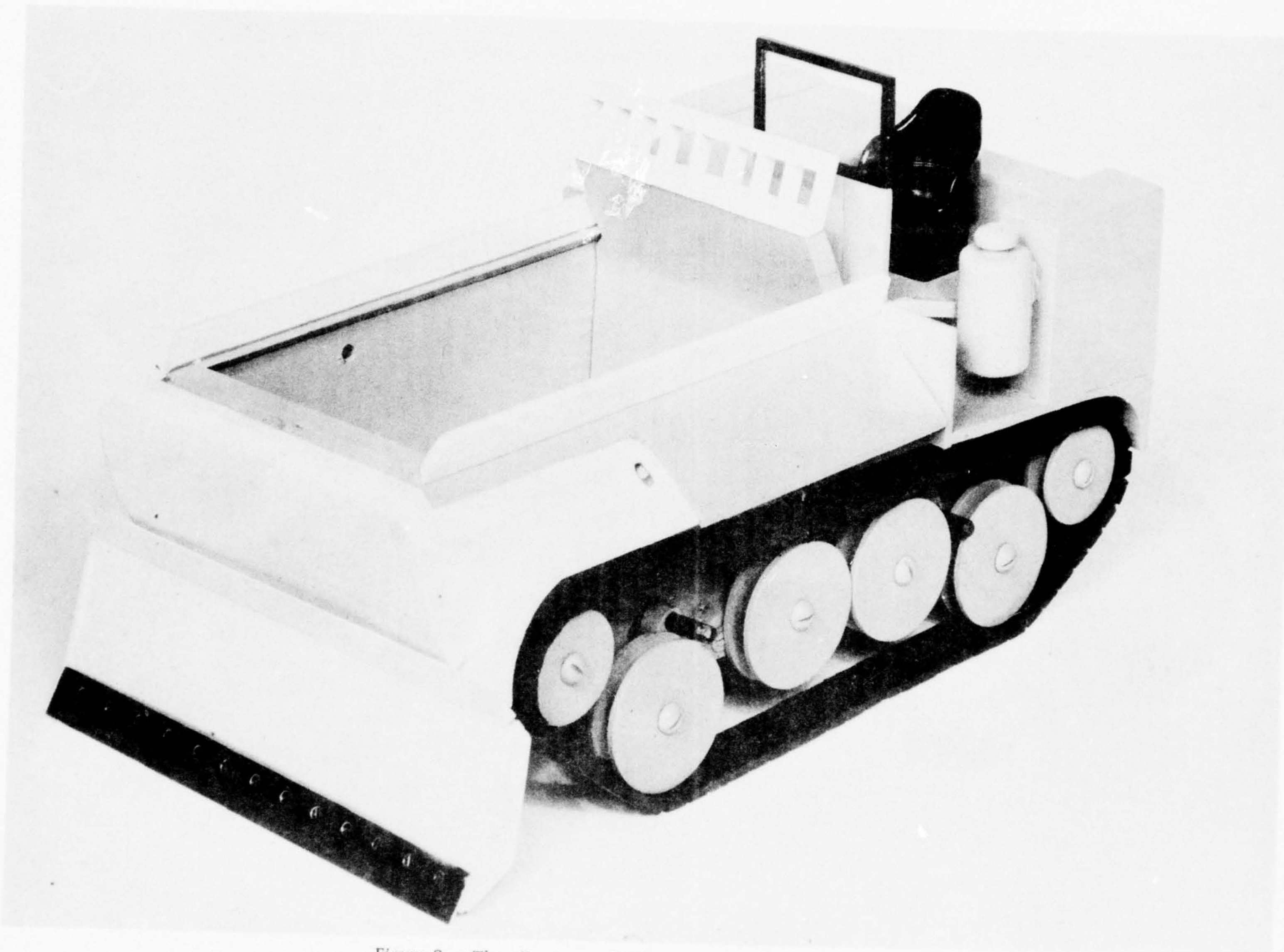


Figure 2. --The all-purpose Ballastable Crawler (ABC)

BAT and ABC design. The unit must also be easily maintained to permit maximum use at the construction site.

The tactical application of a BAT or ABC tractor is illustrated in Figure 3 during a river crossing. Here it can be noted one item of equipment was used to construct both approaches to the river, as well as for numerous other activities including: dozing gun emplacements, transportation, general cargo supplies, POL, personnel, towing artillery, etc. This unit can be used for any normal operations within a combat area. It must be kept in mind, however, that certain capabilities may be somewhat limited in order to provide the multi-purpose capability.

A major contribution of multi-purpose ballastable equipment is that it reduces the number of end items, makes, and models in any given area. It eliminates large operator and maintenance forces of specialized skills. It also reduces overland, water and air transport requirements by wide margins. Table II is a clear indication of the simplification of the logistical load in any given area by using the BAT and ABC tractors vs the items that it replaces. This chart clearly indicates that two basic tractors of military design with a total spare part support of approximately 4,000 line items can replace six end items involving 40 makes and 79 models with a total estimated spare parts support of 161,000 line items. These figures alone should be significant to indicate the terrific reduction of human effort to support future military operations provided standard military vehicles are employed. Simplification of the logistical load can actually be interpreted as an application of human factor engineering since combat forces in the field should be capable of accomplishing the same missions and reach the same goals with greatly reduced efforts from the standpoint of training, supply, as well as administration.

The tractors discussed herein are ballastable units, air droppable (Fig. 4) and/or air transportable in the small assualt type aircraft. These have incorporated in their design capabilities of equipment of twice the size and weight. This is accomplished by ballasting the tractors to their maximum capability and providing a power plant compatible to the increased weight. The basic weight of each unit is 16,000 lbs and each can be ballasted to approximately 35,000 lbs. The BAT and ABC incorporate an engine in the neighborhood of 225 to 250 hp. It is envisioned that eventually these units will be equipped with multi-fuel engines: another effort to reduce logistical requirements.

Based upon tentative design criteria and performance characteristics, the BAT and ABC tractors, it is believed, will have production capabilities ranging from $1\frac{1}{2}$ to 4 times those of the basic earth moving units in the current airborne equipment family. To cite an example, six ABC units should be capable of handling 2,000 cu yd of dirt in four hours, whereas six tractor and scraper combinations of the current airborne family require approximately eleven hours to handle the same quantity of dirt over the same distance.

The BAT and ABC tractors represent the first opportunity to the Corps of Engineers to design a military special end item for the specific purpose of dirt moving in support of combat operations. It is in the best interest of the Corps to insure a successful design to meet the many variables imposed on its combat troops. We, therefore, at the Engineer Laboratories are planning to make maximum use of any scientific methods, techniques, and procedures known regarding human engineering to insure successful employment, operation, maintenance and support of the BAT and ABC tractors.

It is contemplated that future engineer combat and airborne units will be equipped with BAT and ABC machines to carry on a variety of missions including numerous construction operations. The program in general will contribute to the improvement of smaller, faster, more reliable, multi-purpose units over wider and more varied areas than has ever been possible before. It will also provide the combat forces with the mobility which is so vital in current military thinking.

Figure 3. --Tactical application of BAT or ABC

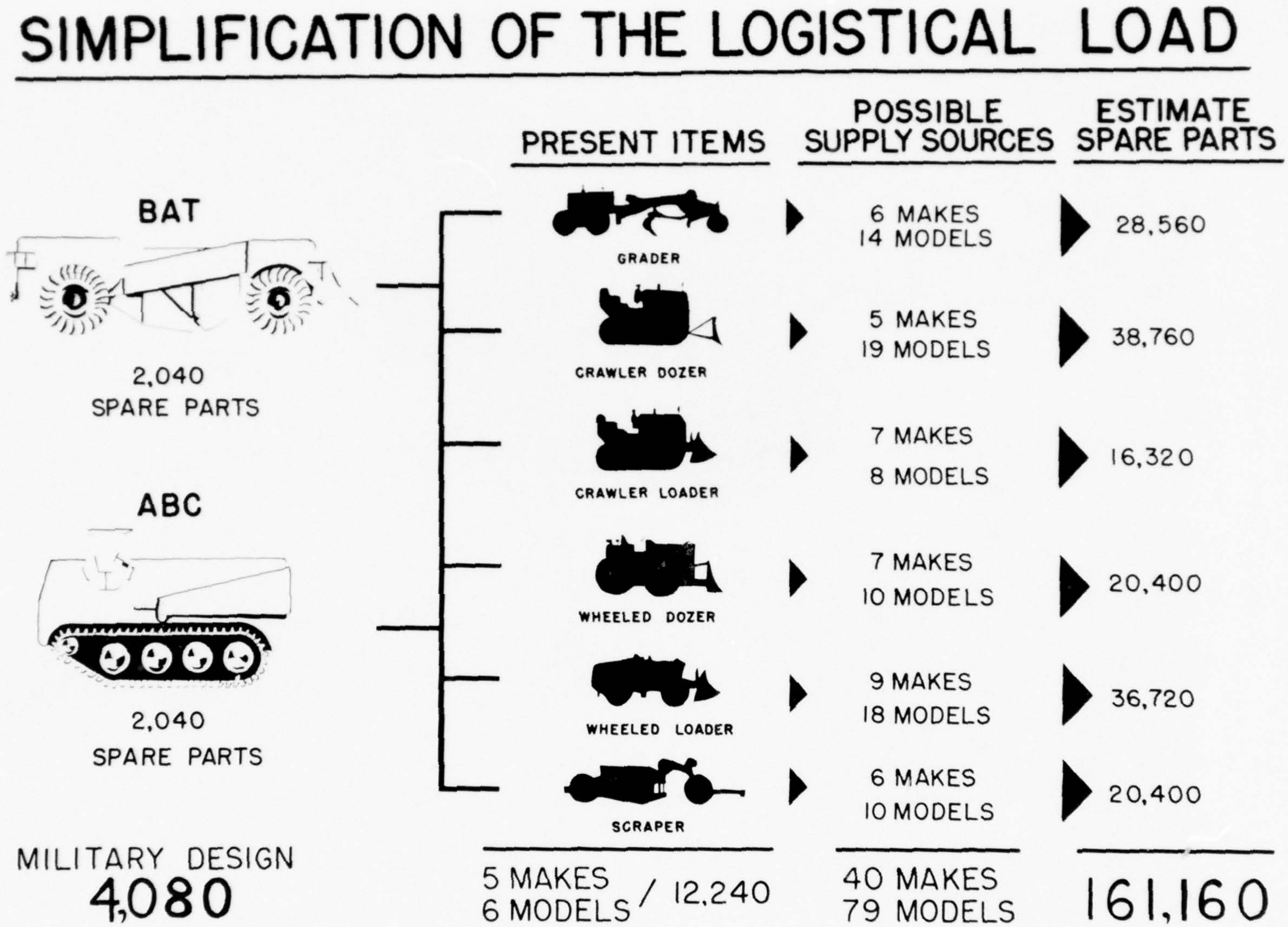


Table II. -- Simplification of the Logistical Load

Figure 4. -- BAT is air droppable.

2. "INFRARED BINOCULARS AND HUMAN ENGINEERING"[1]

by
Mr. Benjamin Goldberg
USAERDL, Ft. Belvoir, Va.

The destructiveness of modern warfare imposes a severe restriction on daytime military operations, and the security afforded by the hours of darkness must be taken advantage of to carry out required combat and support activities. The activities must be carried out with speed and accuracy approaching daylight capability while minimizing the enemy's ability to detect our movements. The use of active infrared radiation provides a means for accomplishing this. What is active infra-red radiation? As most of you know, it is infrared radiation which we project from a searchlight (or floodlight) to irradiate a target to be viewed, just as a searchlight projects visible radiation to illuminate a target to be viewed. The only difference is that the projected infrared radiation is invisible. This invisible beam is reflected from the target and is made visible by an image convertor system placed before the eye (See Fig 1). The two things peculiar to the active infrared system are: the filter that permits only the infrared radiation to pass through; and the image convertor tube which converts the invisible image to a visible one. The remainder of the system is an ordinary light source and reflector for projection, and an optical system for receiving the radiation.

Before going into the discussion of the infrared binoculars, I would like to say something about the filter and image convertor tube. Let us consider the filter first. The filter is made of silicate glass using manganese and chromic oxides as colorants. Its spectral characteristics are shown in Fig 2. Let me point out some interesting facts about this curve. Consider the "toe" of the curve from 700 to 850 millimicrons. The radiation in this region can be detected by the eye, but an observer must be looking directly into a searchlight beam at relatively close range to see anything and then he will see a dull red glow.

Now let us take up the image convertor tube (see Fig 3). This is the heart of any active infrared system. It operates as follows: The infrared image is focused on this surface which is known as the photocathode. The photons from the infrared beam striking the photocathode to produce the image, knock electrons out of the photocathode in proportion to the intensity of the beam at each of the elements of the image. These electrons are accelerated by a 12 KV power supply and strike the phosphor screen to form a visible image of the target. Focusing of the electrons is accomplished by the electrode configuration within the tube. The resolution at the center of the phosphor screen is between 25-30 line pairs per millimeter on the tube cathode.

Now, with the background of basic information I have provided you, let's consider the infrared binoculars, their use and the human engineering problems that were and still are associated with them. The infrared binoculars were developed to provide a means of driving a vehicle in darkness; the purpose being to provide mobility at night approaching daylight capability and with the security of darkness.

Because the infrared binoculars are helmet mounted they leave the operator's hands free to carry out many tasks in darkness with high mobility, and so these binoculars have become the workhorse of the infrared equipment. The Transportation Corps is trying them for locomotive driving and locomotive repair and the Army Ballistic Missile Agency is using them for missile erection and launching operations. They are being used by the Corps of Engineers in construction operations, vehicle repair and bridge building. These bridge operations are being carried out in 150% of daylight time. A particularly interesting use of these binoculars is for helicopter landing in darkness. In this operation the pilot wears the binoculars and locates the landing area by four infrared beacons that bound it. He approaches the landing area until he is several hundred feet over it and then turns on the infrared headlamps mounted underneath the helicopter. This "illuminates" the ground below and the pilot can land his ship.

These binoculars are about to be type classified.

During the course of the development of these binoculars many human engineering problems arose; some were solved, some remain to be solved. First there was a question of bulk, weight and balance. The first binoculars weighed about 6 lbs. Operators would continually get stiff necks and/or headaches. Development of a small power supply, use of special plastics, insulation and electrical connectors in the binocular assembly, resulted in a reduction of weight to 2 lbs. Since the power supply and binocular assembly weigh one pound each, balance is

[1] This is an unclassified paraphrase of Mr. Goldberg's CONFIDENTIAL presentation. Properly authorized individuals may obtain a copy of the full text by application to the Army Research Office, ATTN: Human Factors Research Division, The Pentagon, Washington 25, D. C.

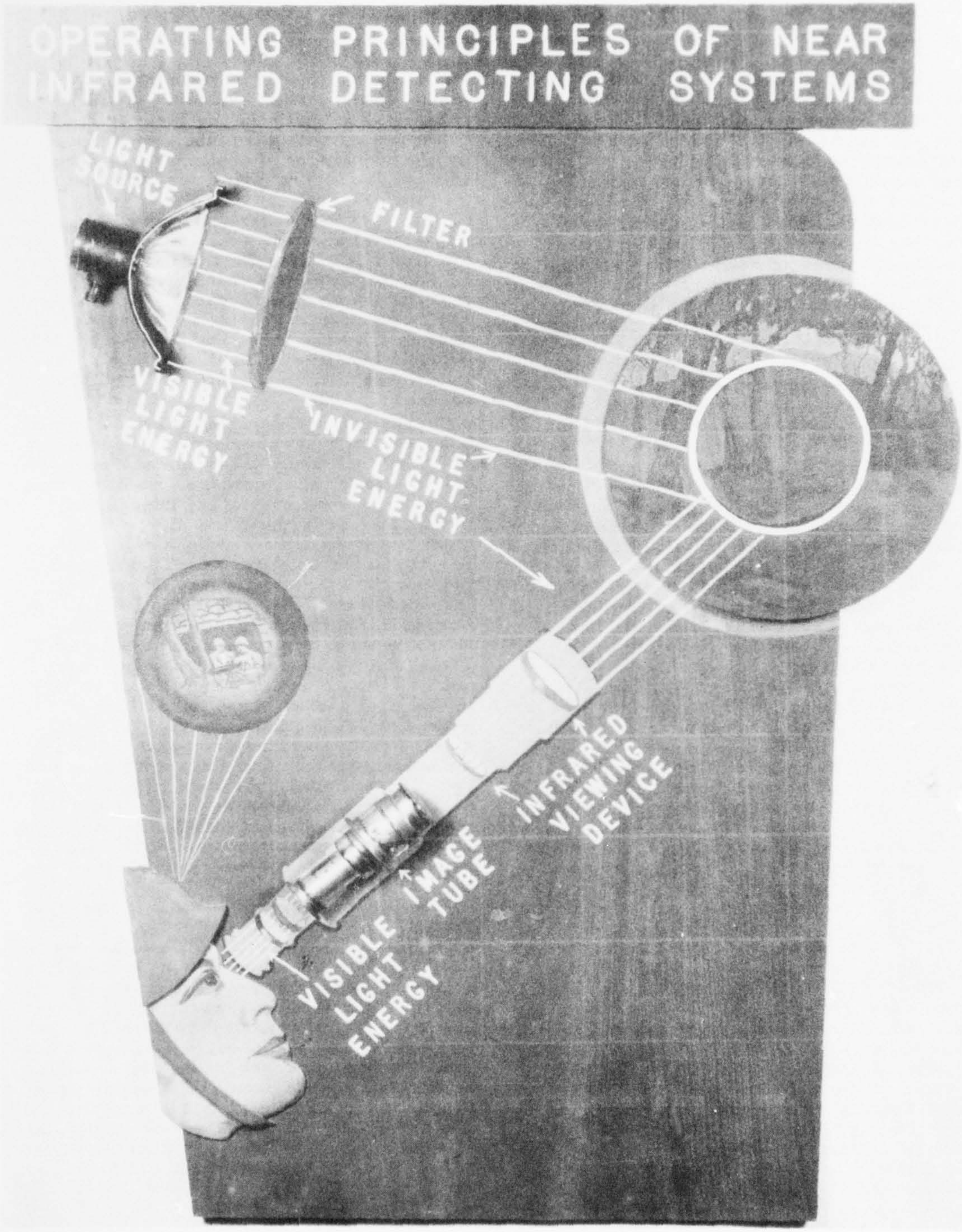
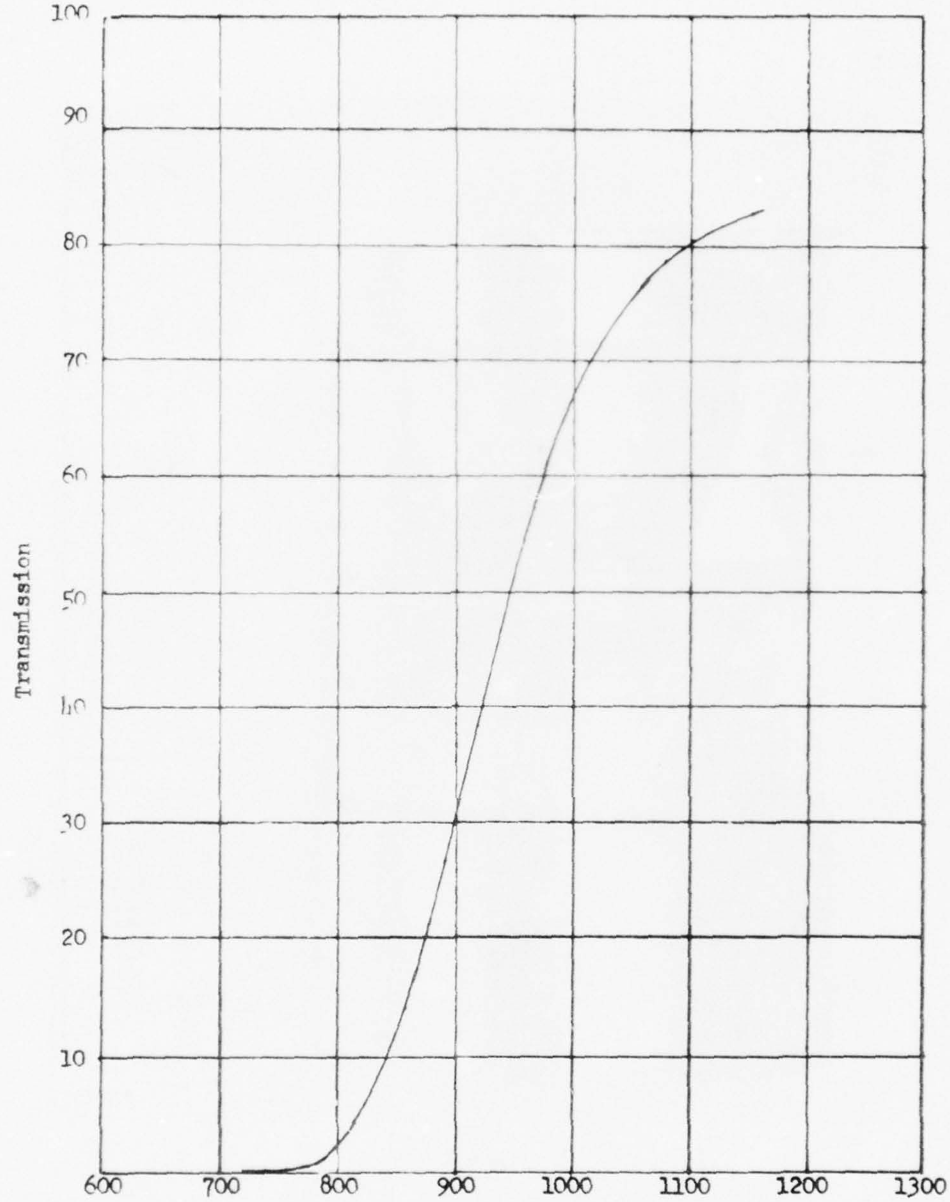

OPERATING PRINCIPLES OF NEAR INFRARED DETECTING SYSTEMS
LIGHT SOURCE
FILTER
VISIBLE LIGHT ENERGY
INVISIBLE LIGHT ENERGY
INFRARED VIEWING DEVICE
IMAGE TUBE
VISIBLE LIGHT ENERGY

Figure 1



Percent transmission vs. wavelength for Gillinder glass filter.

Figure 2

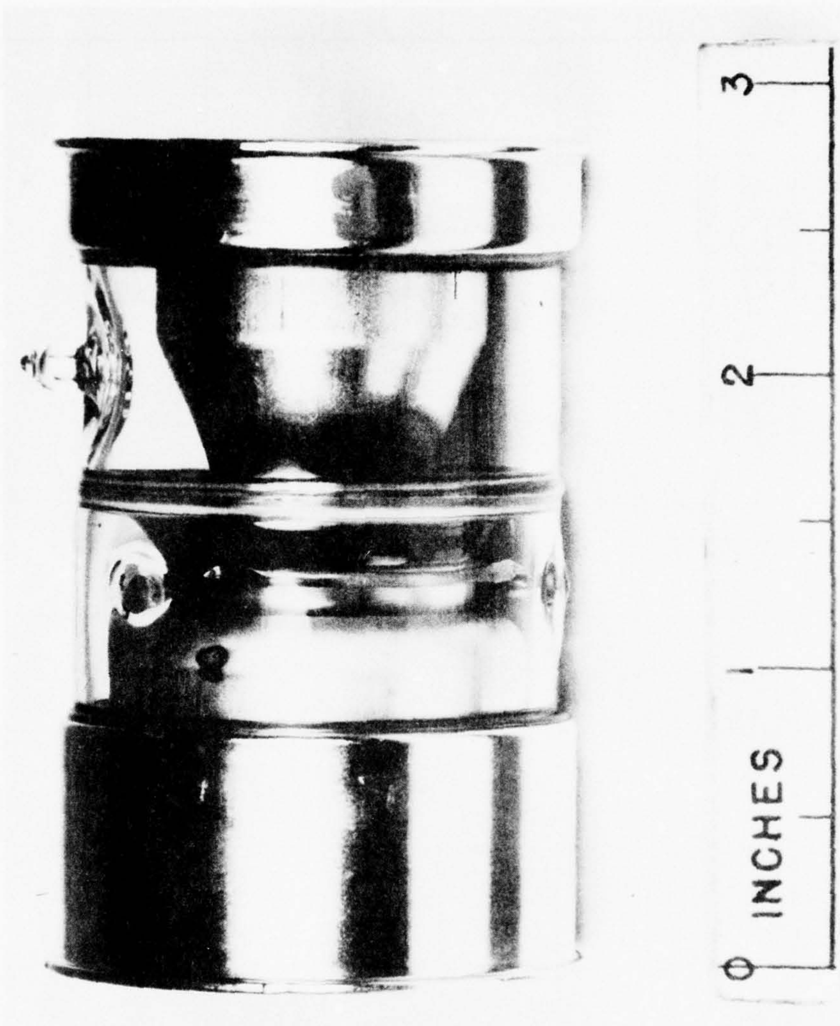


Figure 3

easily achieved on the helmet. Operators using the present binoculars have found them acceptable in comfort. Two other difficulties that arose in the early development stages were discomfort and/or headaches to operators because of unequal magnification between the image tubes in the binocular and unequal brightness levels between the image tubes. This problem was solved by carefully matching tube sets for equal magnification and brightness. Another problem arose on the field of view. Operators wanted fields of view approaching those obtained by normal vision, but the state of the art of optics limits this to the present 27 degrees. There is another aspect to this field-of-view problem which can only be solved by training, and this is the matter of turning corners when you drive. In the normal driving situation when you turn a corner, your eyes flick to the right or left to see where you are going. With driving binoculars, you must move your head to look in the proper direction rather than flick your eyes. This has proven a source of irritation to operators learning to use the binoculars, but eventually they get used to the idea.

Several important human factors problems came to the fore when the binoculars began to find use in close order work such as bridge building, road construction, vehicle maintenance work, and panel reading where operations are carried out from ten inches in front of you to arm's length, or to the ground. Because of the very limited depth of focus of the binoculars at these close ranges, refocusing of the objectives lenses is necessary when viewing at different distances. For example when looking at something 15 inches away and then at an object 25 inches, refocusing is necessary. This is further complicated by the fact that each barrel of the binocular has to be focussed separately. In addition, the barrels of the binocular cannot converge to look at a close-up field. There is another difficulty that arises: In the close order work a false depth of the target is given by the binocular because of its length, the misjudgement of depth being equal to the length of the binocular.

IX. U.S. ARMY SIGNAL CORPS PRESENTATION

"HUMAN FACTORS PROBLEMS OF COMBAT SURVEILLANCE IN MOBILE WARFARE"[1]

by
Dr. Arthur J. Melton
The University of Michigan

This paper considers, in turn, some characteristics of military operations under the PENTANA Concept (1967-1970), the surveillance requirements that must be met for such operations, and some characteristics of the surveillance system, and sensor and information processing subsystems thereof, as derived from participation in Project MICHIGAN's Working Group on Surveillance Sciences in the summer of 1958. On the basis of these considerations, it is concluded that human components will be critical elements of both sensor subsystems and information-processing subsystems of the surveillance system in the 1967-1970 time-period. It is further concluded that the characteristics of PENTANA operations, as well as the anticipated characteristics of the functions assigned to human components in the surveillance system, support the notion that these will be high-level personnel.

The routine application of both human engineering (human factors in system, subsystem and component design) and personnel engineering (selection and training of human components) in an integrated program is recommended. For maintenance personnel and personnel associated with the acquisition of sensor data (pilots, sensor operators, and data-link monitors) such a program will need to be supplemented by limited applied research studies. For the human functions associated with the extraction of information from sensor records and with the collation of information from different sensors and other sources, more substantial basic and applied research and development programs are called for, especially with reference to (1) terrain map content, (2) interpretation of map-like radar, IR, and photographic returns, (3) the programming of sensor analyses in terms of specific questions (contingencies), and (4) the exploitation of time-compression and time-expansion techniques in displays of information.

[1] This is an unclassified abstract of Dr. Melton's SECRET presentation. Properly authorized individuals may obtain a copy of the full text by application to the Army Research Office, ATTN: Human Factors Research Division, The Pentagon, Washington 25, D. C.

APPENDIX 1

ROSTER OF CONFEREES

ABRAHAM, Jeff D.	U. S. Army Electronic Proving Ground Fort Huachuca, Arizona
ACKERMAN, Harry H.	U. S. Army Environmental Health Laboratory Army Chemical Center, Maryland
AIKEN, Marshall D.	Office, Chief Signal Officer Washington 25, D. C.
AUTH, Henry J., Jr.	Directorate for BW Engineering Ft Detrick, Maryland
BAILEY, Dr. John W.	U. S. Army Transportation Research and Engineering Command Fort Eustis, Virginia
BAKER, Dr. Lynn E.	Office, Chief of Research and Development Washington 25, D. C.
BATES, Colonel Raymond H.	U. S. Army Airborne and Electronics Board Fort Bragg, North Carolina
BELL, John B.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
BENNETT, Colonel Eugene G.	U. S. Army Chemical Center and Chemical Corps Materiel Command Army Chemical Center, Maryland
BERGER, Dr. Bernard	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
BERGHOUT, Christian F.	U. S. Army Environmental Health Laboratory Army Chemical Center, Maryland
BOHLER, Major James E.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
BOSWELL, Lt Col Jack	U. S. Army Armor Board Fort Knox, Kentucky
BRIERLY, Dr. William B.	Quartermaster Research and Engineering Center Natick, Massachusetts
BRITTON, Brigadier General F. H.	Director of Developments Office, Chief of Research and Development Washington 25, D. C.
BROWN, Horace E., Jr.	Diamond Ordnance Fuze Laboratories Washington 25, D. C.
BROWN, Dr. John L.	Naval Air Development Center Johnsville, Pennsylvania
BRUCE, Adolph J.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland

BRUCE, John N.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
BUKOWSKI, Henryk J.	U. S. Army Engineer Maintenance Center Columbus, Ohio
BURGE, Robert George	U. S. Army Chemical Corps Proving Ground Dugway, Utah
BUTLER, Charles A.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
CABREY, George J.	U. S. Army Chemical Corps Proving Ground Dugway, Utah
CALDWELL, John A.	U. S. Army Engineer Research and Development Laboratories Fort Belvoir, Virginia
CAPASSO, Nicholas S.	Hq, U. S. Army Chemical Corps Research and Development Command Washington 25, D. C.
CHAMBERS, Dr. William H.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
CHIMINIELLO, Colonel Dominic J.	U. S. Army Chemical Center and Chemical Corps Materiel Command Army Chemical Center, Maryland
CONWAY, Brigadier General T. J.	Director, Army Research Office Office, Chief of Research and Development Washington 25, D. C.
COOKE, Alfred A.	U. S. Army Chemical Center and Chemical Corps Materiel Command Army Chemical Center, Maryland
COTNAM, Pfc. John D.	Frankford Arsenal Philadelphia, Pennsylvania
COX, Robert E.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
CROSSEN, John	U. S. Army Chemical Corps Proving Ground Dugway, Utah
CRUSE, Charles S.	Human Engineering Laboratory Aberdeen Proving Ground, Maryland
DALEY, Major General John P.	Director, Special Weapons Office, Chief of Research and Development Washington 25, D. C.
DAUER, Lt Col Maxwell	U. S. Army Environmental Health Laboratory Army Chemical Center, Maryland
DAVY, Dr. Earl	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
DEMITRACK, George	Picatinny Arsenal Dover, New Jersey
DeROY, Glennon L.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland

DeTOGNI, G. R.	Watervliet Arsenal Watervliet, New York
DITTMAN, Paul E.	AFOSR, Room 2834, Tempo X 19th & E. Capitol Washington, D. C.
DORFMAN, Abraham L.	Picatinny Arsenal Dover, New Jersey
DOYLE, Captain Alfred P.	U. S. Army Environmental Health Laboratory Army Chemical Center, Maryland
DRENNON, Colonel C. B., Jr.	U. S. Army Chemical Center and Chemical Corps Materiel Command Army Chemical Center, Maryland
DUGUID, Robert H.	U. S. Army Environmental Health Laboratory Army Chemical Center, Maryland
DUSEK, Dr. Edwin Ralph	Quartermaster Research and Engineering Center Natick, Massachusetts
DZIEMIAN, Dr. Arthur J.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
EARLE, Major Hilton H., Jr.	U. S. Army Environmental Health Laboratory Army Chemical Center, Maryland
ECKLES, Andrew J.	The Johns Hopkins University 7100 Connecticut Avenue Washington 15, D. C.
EDWARDS, Ward Dennis	The University of Michigan Willow Run Laboratories Ypsilanti, Michigan
ENGQUIST, Elmer H.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
ENY, Dr. Desire M.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
ERNST, Harry William	Watertown Arsenal Watertown, Massachusetts
ESCHBACH, Captain Robert E.	U. S. Army Environmental Health Laboratory Army Chemical Center, Maryland
ESPENSCHADE, Park W.	Office of Ordnance Research Duke Station Durham, North Carolina
ESSMAN, Colonel Graydon C.	Hq, U. S. Army Chemical Corps Research and Development Command Washington 25, D. C.
EWBANK, Colonel Keith H.	U. S. Continental Army Command Fort Monroe, Virginia
FEDDERSEN, Dr. William E.	Bell Helicopter Corporation Fort Worth, Texas
FELLENZ, Colonel L. E.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland

FINAN, Dr. John L.	Human Resources Research Office Post Office Box 3596 Washington 7, D. C.
FLEMING, Gerald J.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
FOLEY, Colonel William	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
FOSTER, Mrs. Harriet Wilson	The University of Michigan Willow Run Laboratories Ypsilanti, Michigan
FROLICH, Dr. Per K	Office, Chief Chemical Officer Gravelly Point, Virginia
GARONO, Louis E.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
GASTON, Lt Col Daniel J.	Office of the Chief Chemical Officer Washington 25, D. C.
GAVURIN, Edward L.	U. S. Naval Training Device Center Port Washington Long Island, New York
GEARAN, Captain William K.	U. S. Army Aviation Board Fort Rucker, Alabama
GELDARD, Dr. Frank A.	University of Virginia Charlottesville, Virginia
GIBSON, Pfc. Dale	Frankford Arsenal Philadelphia, Pennsylvania
GILLEN, Major Frederick R.	Air Research and Development Command Andrews Air Force Base Washington 25, D. C.
GOLDBERG, Benjamin	Engineer Research and Development Laboratories Fort Belvoir, Virginia
GOLDMAN, Alexander	U. S. Naval Training Device Center Port Washington Long Island, New York
GOSSARD, Donald I.	U. S. Army Chemical Center and Chemical Corps Materiel Command Army Chemical Center, Maryland
GOTOFF, Harold L.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
GRAHAM, Donald I., Jr.	U. S. Army Rocket and Guided Missile Agency Huntsville, Alabama
GREENE, Dr. L. Wilson	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
GREENWAY, Ralph B.	Office of the Deputy Chief of Staff for Military Operations Washington 25, D. C.

GRIFFITH, Paul E.	U. S. Army Signal Research and Development Laboratory (SIGFM/EL-ENS) Fort Monmouth, New Jersey
GROSS, William E.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
GUEDRY, Dr. Frederick E., Jr.	U. S. Army Medical Research Laboratory Fort Knox, Kentucky
GUEYMARD, Lt Col Joffre L.	Army Research Office Office, Chief of Research and Development Washington 25, D. C.
HAND, Lt Col Robert E.	U. S. Army Artillery Board Fort Sill, Oklahoma
HANSEN, Alfred A. E.	Detroit Arsenal Center Line, Michigan
HARMON, William S.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
HARRIS, Dr. Frank J.	The Johns Hopkins University 7100 Connecticut Avenue Washington 15, D. C.
HARROD, Edgar B., Jr.	Directorate for BW Engineering Ft Detrick, Maryland
HATFIELD, 1st Lt Jimmy L.	U. S. Army Medical Research Laboratory Fort Knox, Kentucky
HEIDEL, William E., Jr.	Rock Island Arsenal Rock Island, Illinois
HENDERSON, Robert D.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
HENSCHEL, Dr. Austin	Quartermaster Research and Engineering Center Natick, Massachusetts
HERBERT, Dr. Marvin J.	U. S. Army Medical Research Laboratory Fort Knox, Kentucky
HERGET, Dr. C. M.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
HICKS, Colonel Herbert C., Jr.	Army Research Office Office, Chief of Research and Development Washington 25, D. C.
HILL, Colonel Charles W.	Office of The Surgeon General Washington 25. D. C.
HILL, Major Ralph J.	U. S. Continental Army Command Fort Monroe, Virginia
HOYT, Dr. Ruth	Defense Research Board Department of National Defense Ottawa, Canada
HUBER, Roy L.	Detroit Arsenal Center Line, Michigan

HUNTLEY, Paul C.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
HUSS, Harry O.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
INSLERMAN, Hans E.	U. S. Army Signal Research and Development Laboratory Fort Monmouth, New Jersey
ISMACH, Aaron	Medical Equipment Development Laboratory Fort Totten, New York
IVEY, Mrs. Lois F.	Human Engineering Laboratory Aberdeen Proving Ground, Maryland
JAMIESON, Archibald L.	Frankford Arsenal Philadelphia, Pennsylvania
JARMAN, Gordon J.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
JELINEK, Robert E.	Human Engineering Laboratory Aberdeen Proving Ground, Maryland
JOHNS, Bert J.	U. S. Army Chemical Corps Proving Ground Dugway, Utah
JOHNSON, William A.	Rock Island Arsenal Rock Island, Illinois
JOHNSON, LCDR Woodbury	Bureau of Aeronautics Department of the Navy Washington 25, D. C.
JOHNSTON, James H.	U. S. Army Signal Research and Development Laboratory (SIGFM/EL-NE) Fort Monmouth, New Jersey
JONAS, Leonard A.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
KAPPAUF, Dr. William E. Jr.	University of Illinois Urbana, Illinois
KARPEL, Bertram L.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
KARR, A. Charles	Frankford Arsenal Philadelphia, Pennsylvania
KATCHMAR, Dr. Leon T.	Human Engineering Laboratory Aberdeen Proving Ground, Maryland
KAUFMAN, Joseph	Office, Chief of Ordnance Washington 25, D. C.
KEENE, Wilson B.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
KELLY, Earl S.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
KENNEDY, Dr. Stephen J.	Quartermaster Research and Engineering Center Natick, Massachusetts

KERSCHENSTEINER, Max	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
KILLPACK, Major Paul E.	Air Mobility Division Office, Chief of Research and Development Washington 25, D. C.
KING, Dr. Samuel H.	Personnel Research Branch Office of The Adjutant General Washington, D. C.
KITTS, Howard L.	U. S. Army Signal Research and Development Laboratory (SIGFM/EL-NR) Fort Monmouth, New Jersey
KOBRICK, Dr. John L., Jr.	Quartermaster Research and Engineering Center Natick, Massachusetts
KOLOVOS, Captain E. R.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
KRAMER, Dr. Donald N.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
LAICHE, Lt Col Wendel E.	Office of the Deputy Chief of Staff for Personnel Department of the Army Washington 25, D. C.
LANARD, Lt Col Francis W.	U. S. Army Environmental Health Laboratory Army Chemical Center, Maryland
LANE, Lt Col Jack F.	U. S. Army Chemical Corps Operations Research Group Army Chemical Center, Maryland
LEBEDDA, John M.	U. S. Army Signal Research and Development Laboratory Fort Monmouth, New Jersey
LEVIN, Alexander	Quartermaster Research and Engineering Center Natick, Massachusetts
LINKOUS, Walter W.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
LIPTON, Milton A.	U. S. Army Signal Research and Development Laboratory Fort Monmouth, New Jersey
LIZZA, Albert J.	Springfield Armory Springfield 1, Massachusetts
LIT, Alfred	University of Michigan Research Institute Ann Arbor, Michigan
LOCKSLEY, Lt Col Norman M. G.	Office of the Deputy Chief of Staff for Personnel Department of the Army Washington 25, D. C.
LORENZEN, Theodore G., Jr.	Ordnance Weapons Command Rock Island, Illinois
LOVE, Solomon	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland

LUCIA, Harry S., Jr.	U. S. Army Biological Warfare Laboratories Fort Detrick, Maryland
LUND, Dr. Max W.	Office of Naval Research Washington 25, D. C.
McCORMICK, Dr. Ernest J.	Occupational Research Center Purdue University Lafayette, Indiana
MARKS, Dr. Melvin R.	Personnel Research Branch Office of The Adjutant General Washington 25, D. C.
MARSH, Colonel Clarence T., Jr.	U. S. Army Air Defense Board Fort Bliss, Texas
MARTIN, Colonel John A.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
MARTIN, Colonel Ronald L.	U. S. Army Chemical Corps Research and Development Command Washington 25, D. C.
MARZULLI, Dr. Francis N.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
MAXA, Jerry F.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
MEAD, Dr. Leonard C.	Tufts University Medford 55, Massachusetts
MEADERS, Lt Col George E.	Office of the Deputy Chief of Staff for Logistics Department of the Army Washington 25, D. C.
MEALS, Dr. Donald W.	U. S. Continental Army Command Fort Monroe, Virginia
MELTON, Arthur W.	The University of Michigan Willow Run Laboratories Ypsilanti, Michigan
METCALF, Dr. Edward A.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
MILLER, Major Adelbert E.	U. S. Army Chemical Center and Chemical Corps Materiel Command Army Chemical Center, Maryland
MILLER, Charles E.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
MITCHELL, 2d Lt Allston T.	U. S. Army Environmental Health Laboratory Army Chemical Center, Maryland
MITCHELL, James P.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
MITNICK, Dr. Leonard L.	Human Resources Research Office Post Office Box 3596 Washington 7, D. C.
MOODY, Lt John A.	U. S. Naval Submarine Base New London, Connecticut

MORDEN, Lt Col Harold R.	Medical Equipment Development Laboratory Fort Totten, New York
MORGAN, Irving B.	Office of the Chief Chemical Officer Gravelly Point, Virginia
MOSELEY, Kenneth P.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
MUTH, Colonel Roy W.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
NEIBUHR, Henry J.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
NEWMAN, Dr. Russell W.	Quartermaster Research and Engineering Center Natick, Massacusetts
NOYES, Robert H.	U. S. Army Signal Research and Development Laboratory (SIGFM/EL-TPS) Fort Monmouth, New Jersey
OGILVIE, Dr. John	Defense Research Medical Laboratories Toronto, Canada
OLEJAR, Paul D.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
PANAK, Leon P.	U. S. Army Signal Research and Development Laboratory Fort Monmouth, New Jersey
PECZENIK, Major Alois	U. S. Army Environmental Health Laboratory Army Chemical Center, Maryland
PILE, Benjamin D.	Medical Equipment Development Laboratory Fort Totten, New York
POTASH, Norman	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
PROTO, Pasquale P.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
RASSMAN, Ernest	Bureau of Ships Department of the Navy Washington 25, D. C.
RAUN, Milton A.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
RENDA, John D.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
REYNOLDS, Paul E.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
RIOPELLE, Dr. Arthur J.	U. S. Army Medical Research Laboratory Fort Knox, Kentucky
ROBERTS, William B.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
ROCK, Eugene T.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland

ROCKWELL, Dr. Thomas H.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
ROGERS, Frank A.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
ROLLINS, John H.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
ROSENFELD, David A.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
ROUSE, Harrison, V., Jr.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
RUSSEL, Dr. Roger W.	American Psychological Association Washington, D. C.
SALAMON, Mrs. Meirel K.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
SAWYER, Ephriam L.	U. S. Army Chemical Corps Board Army Chemical Center, Maryland
SCHNECK, David	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
SCHOEFFLER, Max S.	The University of Michigan Willow Run Laboratories Ypsilanti, Michigan
SCHRAMM, H. Kenneth	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
SCHWANKE, Edmund H.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
SEIBERT, Lawrence H.	U. S. Army Signal Research and Development Laboratory Fort Monmouth, New Jersey
SEIGNEUR, Captain William B.	U. S. Army Environmental Health Laboratory Army Chemical Center, Maryland
SEMINARA, Joseph L.	Picatinny Arsenal Dover, New Jersey
SHANTY, Frank	U. S. Army Chemical Warfare Laboratory Army Chemical Center, Maryland
SHEARIN, William H.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
SHELOR, Richard S.	Directorate for BW Engineering Fort Detrick, Maryland
SHERMAN, Mr. Irving S.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
SHON, Milton	U. S. Army Biological Warfare Laboratories Fort Detrick, Maryland
SIEBEN, Major Herbert U.	U. S. Army Infantry Board Fort Benning, Georgia

SIEGEL, Bernard	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
SIGLER, Edwin Barnes	Ordnance Weapons Command Rock Island, Illinois
SILVER, Dr. S. D.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
SINCLITICO, Anthony N.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
SLAUTA, John	Quartermaster Research and Engineering Center Natick, Massachusetts
SNELL, Mr. Elliott A.	Quartermaster Research and Engineering Center Natick, Massachusetts
SPENCE, Major Judson C., Sr.	U. S. Army Infantry Board Fort Benning, Georgia
SPENCE, Dr. Kenneth W., Jr.	State University of Iowa Iowa City, Iowa
SPERLING, Dr. Philip Irving	Office of The Surgeon General Washington, D. C.
SPRAGUE, George F.	U. S. Army Environmental Health Laboratory Army Chemical Center, Maryland
STARK, Dr. Edward A.	U. S. Continental Army Command Fort Knox, Kentucky
STELLE, Donald R.	U. S. Army Signal Research and Development Laboratory (SIGFM/EL-PS) Fort Monmouth, New Jersey
STENGLE, Francis W.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
STEPHENS, John A.	Human Engineering Laboratory Aberdeen Proving Ground, Maryland
STOREY, Lt Col R. C.	Office, Deputy Chief of Staff for Personnel Department of the Army Washington 25, D. C.
STUBBS, Major General Marshall	Chief Chemical Officer Department of the Army Washington 25, D. C.
SUMMERSON, Dr. William H.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
TAYLOR, Dr. Franklin Veazey	Naval Research Laboratory Washington 25, D. C.
TEICHNER, Dr. Warren H.	Frankford Arsenal Philadelphia, Pennsylvania
TIMBERLAKE, Turner G.	Engineer Research and Development Laboratories Fort Belvoir, Virginia
TITCOMB, George P.	U. S. Army Chemical Center and Chemical Corps Materiel Command Army Chemical Center, Maryland

TOMASO, Albert N.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
TRAUB, Hohn L.	U. S. Army Chemical Center and Chemical Corps Materiel Command Army Chemical Center, Maryland
TREBILCOCK, John L.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
TREGLIA, Thomas A.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
TUCCI, Serafino	U. S. Army Signal Research and Development Laboratory (SIGFM/EL-FAE) Fort Monmouth, New Jersey
TUDOR, 1st Lieutenant Walter J.	U. S. Army Environmental Health Laboratory Army Chemical Center, Maryland
ULRICH, Lt Col John A.	Diamond Ordnance Fuze Laboratories Washington 25, D. C.
VENIAR, Dr. Seymour	University of Michigan Willow Run Laboratories Ypsilanti, Michigan
VINING, Theron M.	U. S. Army Chemical Corps Engineering Command Army Chemical Center, Maryland
VROOMAN, Alonzo J.	Engineer Research and Development Laboratories Fort Belvoir, Virginia
WALKER, Dr. Edward Lewis	University of Michigan Willow Run Laboratories Ypsilanti, Michigan
WALLACE, Dr. S. Rains	Life Insurance Agency Management Association 855 Asylum Avenue Hartford, Connecticut
WALMSLEY Harold Brigadier General	Commanding General U. S. Army Chemical Center and Chemical Corps Materiel Command Army Chemical Center, Maryland
WEBBER, Lt Col Ira B.	USCONARC Liaison Officer Army Chemical Center, Maryland
WEBER, William J.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
WEINBERG, David L.	U. S. Army Signal Research and Development Laboratory (SIGFM/EL-SV) Fort Monmouth, New Jersey
WEISZ, Dr. John D.	Human Engineering Laboratory Aberdeen Proving Ground, Maryland
WEST, Allan L. J.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
WHITAKER, Henry R.	U. S. Army Chemical Corps Proving Ground Dugway, Utah

WHITNEY, Lt Col Carl L.	Commanding Officer Quartermaster Research and Engineering Center Natick, Massachusetts
WICKENS, Dr. Delos D.	Ohio State University Columbus 10, Ohio
WILLIAMS, Lt Gen E. T.	Deputy Commanding General U. S. Continental Army Command Fort Monroe, Virginia
WILLMANN, Lt Col William G.	Office of the Chief Chemical Officer Washington 25, D. C.
WISEMAN, William J., Jr.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
WITTEN, Dr. Benjamin	U. S. Army Chemical Warefare Laboratories Army Chemical Center, Maryland
WOODWARD, Dr. Arthur A., Jr.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
WRIGHT, Miss Natalie L.	Picatinny Arsenal Dover, New Jersey
WYLIE, Dr. Donald P.	Office of Ordnance Research U. S. Army, Box CM Duke Station Durham, North Carolina
WYLY, James J., Jr.	U. S. Army Signal Research and Development Laboratory (SIGFM/EL-FAM) Fort Monmouth, New Jersey
ZEFFERT, Dr. Bernard M.	U. S. Army Chemical Warfare Laboratories Army Chemical Center, Maryland
ZELENY, Charles E.	U. S. Army Electronic Proving Ground Fort Huachuca, Arizona
ZIMMER, Randolph	U. S. Army Signal Research and Development Laboratory Fort Monmouth, New Jersey

APPENDIX 2

4th ANNUAL

ARMY HUMAN FACTORS ENGINEERING CONFERENCE

ARMY CHEMICAL CENTER, MD.

9-11 SEPTEMBER 1958

VITAE, CURRENT WORK PROGRAMS, AND BIBLIOGRAPHIES IN

PSYCHOPHYSIOLOGY AND HUMAN FACTORS ENGINEERING

[These materials were furnished to conferees for their study and convenience in advance of the Conference. They are published here as an annual compendium of the activities and work programs of all Army R&D psychophysiology and human factors engineering facilities.]

APPENDIX 2

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PROGRAM
FOURTH ANNUAL ARMY HUMAN FACTORS ENGINEERING CONFERENCE
ARMY CHEMICAL CENTER, MARYLAND

9-11 SEPTEMBER 1958

TUESDAY, 9 SEPTEMBER 1958

0930-1030 Registration

MORNING SESSION

Session Chairman: Dr. Lynn E. Baker, U. S. Army Chief Psychologist, Office of the Chief of Research and Development (OCRD), Department of the Army (DA).

1030 Opening of the Conference: Session Chairman

Invocation by Maj Lawrence H. Jongewaard, Post Chaplain, Army Chemical Center.

Welcoming Address by Brig Gen Harold Walmsley, Commanding General, U. S. Army Chemical Center and Chemical Corps Materiel Command, Army Chemical Center, Md.

1100 Introduction of Keynote Speaker by MajGen John P. Daley, Director Special Weapons, Office of the Chief of Research and Development, Department of the Army.

Keynote Address:

"The New Mobile Concept," by LtGen Edward T. Williams, Deputy Commanding General, United States Continental Army Command.

1200 U. S. Army Signal Corps Film Presentation:

"Army-Navy Instrumentation Program (ANIP)"

1230 LUNCH

AFTERNOON SESSION

Session Chairman: Col William Foley, Deputy Commander, U. S. Army Chemical Corps Engineering Command

1400 U. S. Continental Army Command (USCONARC) Presentation:

"Human Factors in User Testing Resulting from Concepts Expressed by Lt Gen Williams," by Col Keith Ewbank, USCONARC.

1500 U. S. Army Chemical Corps Presentation:

"Development of Chemical Corps Materiel for the Mobile Army," by Lt Col W. G. Willman, Office of the Chief Chemical Officer.

1600 U. S. Army Medical Services Presentations:

"Selected Medical Service Research Contributing to Human Factors Engineering for Mobility," by Dr. Arthur J. Riopelle, Army Medical Research Laboratories (AMRL).

"Decrements in Driving Skill as a Function of Cumulative Environmental Stresses," by Dr. M. J. Herbert, AMRL.

"Vestibular Functions in Angular Acceleration," by Dr. F. E. Guedry, AMRL.

1730-1900 Social Function

[Buses will depart for Hotel Emerson, Baltimore, at 1900 hours]

WEDNESDAY, 10 SEPTEMBER 1958

MORNING SESSION
Session Chairman: Mr. Nicholas S. Capasso, U. S. Army Chemical Corps Research and Development Command.

0900 U. S. Army Ordnance Corps Presentation:
"Ordnance Design Concepts for Ground Mobility," by Mr. Donald Wylie, Office of Ordnance Research (OOR).

1030 U. S. Army Quartermaster Corps Presentations:
"Minimal Subsistence Requirements to Maintain Performance," by Dr. Austin Henschel, Quartermaster Research and Engineering Command (QMR&EC).
"Small Unit Clothing Tariffs," by Dr. Russel W. Newman, QMR&EC.
"Environmental Criteria for Equipment Design," by Dr. William B. Brierly, QMR&EC.

AFTERNOON SESSION
Session Chairman: Dr. Earl Davy, Chief, Psychology and Human Engineering Branch, U. S. Army Chemical Warfare Laboratories.

1330 U. S. Army Transportation Corps Presentation:
"Ground Mobility and Transportation," by Dr. John Wendell Bailey, Transportation Corps Research and Engineering Command (TRECOM).

1430 Chemical-Biological-Radiological (CBR) Orientation and Demonstrations.

THURSDAY, 11 SEPTEMBER 1958

MORNING SESSION
Session Chairman: Col John A. Martin, Director of Development, U. S. Army Chemical Warfare Laboratories.

0900 U. S. Army Corps of Engineers Presentations:
"Human Engineering in Corps of Engineers Equipment Design," by Mr. Turner G. Timberlake, Chief, Mechanical Engineering Department, Engineer Research and Development Laboratories (ERDL).
"Infrared Binoculars and Human Engineering," by Mr. Ben Goldberg, Chief, Warfare Vision Branch, ERDL.

1000 U. S. Army Signal Corps Presentation:
"Human Factors Problems of Combat Surveillance in Mobile Warfare," by Dr. Arthur W. Melton, University of Michigan.

1100 Conference Highlights and Summary:
Dr. Lynn E. Baker, U. S. Army Chief Psychologist, OCRD, DA.

1200 Adjourn.

U. S. ARMY MEDICAL SERVICE

Research Program in Psychophysiology

I. Vitae, US Army Medical Research Laboratory, Fort Knox, Kentucky

II. Current Studies

III. Bibliography of Published Reports

I. VITAE

CADWALLADER, THOMAS C., Lt., MSC, Psychologist
PhD, University of Buffalo, 1958.
Physiological psychology.

CALDWELL, LEE S., Psychophysiologist
PhD, University of Kentucky, 1955.
Biomechanics.

CRAMER, ROBERT L., Psychophysiologist
PhD, University of Rochester, 1954.
Vestibular functions.

CRAMPTON, GEORGE H., Capt., MSC, Psychologist
PhD, University of Rochester, 1954.
Vestibular functions.

DAUBEK, GERALD G., Psychologist
MS, University of Illinois, 1955.
Educational psychology.

FLETCHER, JOHN L., Capt., MSC, Head, Audition Section
PhD, University of Kentucky, 1955.
Audition.

GOGEL, WALTER C., Psychophysiologist
PhD, University of Chicago, 1951.
Vision.

GUEDRY, FRED E., JR., Head, Proprioception Section
PhD, Tulane University, 1953.
Vestibular psychophysiology.

HARKER, GEORGE S., Head, Vision Section
PhD, State University of Iowa, 1950.
Vision.

HAWKES, GLENN R., 1st Lt., MSC, Psychologist
PhD, University of Virginia, 1958.
Physiological psychology.

HERBERT, MARVIN J., Head, Psychomotor Section
PhD, University of Minnesota, 1953.
Motor skills.

LOEB, MICHEL, Psychophysiologist
PhD, Vanderbilt University, 1953.
Auditory functions.

MONTAGUE, ERNEST K., Lt. Col., MSC, Deputy Head, Experimental Psychology Department,
PhD, State University of Iowa, 1950.
General psychology.

RIOPELLE, ARTHUR J., Head, Experimental Psychology Department
PhD, University of Wisconsin, 1950.
Primate behavior.

ROSS, WILLIAM, Capt, MC
MD, Northwestern University, 1956.
Physiology.

SCHAEFER, VERNON H., 1st Lt., MSC, Psychologist
PhD, University of Illinois, 1957.
Experimental psychology.

II. CURRENT STUDIES

TASK I--Investigation of Sound and Hearing in Relation to Performance

Subtask 1: Hearing Loss and Noise Exposure

Title	Experimenter	Date Started	Estimated Completion Date
a. Factors in Sound-Induced Hearing Loss	Fletcher	Aug 57	Aug 60

Reference audiograms are being obtained on all incoming personnel in a group of 120 range operators. Cumulative noise exposure indices will be obtained for each person over a period of 18 - 36 months. Analyses will be made to relate hearing loss to exposure, hearing conservation practices, and physical factors such as aural overload threshold, family history, medical history, and type of audiogram.

b. Impulsive vs Continuous Noises	Fletcher	May 57	Completed

A report on the relative influence on hearing of impulse noise and continuous noise has been completed, and future studies involving the measurement of impulse noise and its relationship to hearing loss are planned.

c. Prediction of Deafness	Fletcher	May 57	Oct 58

Possible predictors of susceptibility to deafness, such as short-term fatigue, masking effects, etc., will be investigated.

d. The Effect of Overstimulation and Internal Factors on the Function of the Inner Ear (DA-49-007-634)	Lawrence U. of Michigan	May 55	Jun 60

The reported results on this continuing study indicate the following: (1) the measurement of bone-conduction thresholds may give an inaccurate picture of the true capacility of the organ of Corti whereas the aural-harmonic test proves to be quite valid and stable; (2) the use of a loudness attenuator instead of an intensity attenuator in automatic audiometry provides a more sensitive test of recruitment since the subjects apparently respond to a growth of loudness unrelated to size of DL's; (3) intense sound of a sound pressure level of 136 and 150 decibels damages the saccule as well as portions of the cochlea. This observation may account in part for the disorientation experienced by humans when subjected to an intense sound field; (4) study of the nature of neural innervation of the cochlea have not yet been completed.

e. Measurement of Noises Produced by US Army Weapons (DA-49-007-MD-being negotiated)	Bolt, Beranek & Newman, Inc. Cambridge, Mass.	Jul 58	Jun 59

A method of measuring and analyzing the impulse-type noises from various U.S. Army weapons is being sought. An attempt will be made to gather data in the field in such a form that they may be usable for comparison with data concerning hearing loss and possibly with data descriptive of the attenuation characteristics of various ear defenders being used in the military.

Subtask 2: The Auditory "Sharpening" Phenomenon

Title	Experimenter	Date Started	Estimated Completion Date
a. Frequency-Difference Thresholds	Silver	Aug 57	Sep 58

The determination of the frequency-difference threshold about a stimulated point was made using recently discovered interaural inhibition to avoid the difficulties imposed by head phenomena. Using pure tone to produce contralateral inhibition, the absolute threshold for intensity was investigated in the region around the center of the contralateral inhibition. The experimental work has been completed, and the report is being written. The principal investigator has left the laboratory and no future work on this problem is contemplated.

Subtask 3: Experiments on Absolute Threshold

Title	Experimenter	Date Started	Estimated Completion Date
a. Practice Effects	Loeb	Aug 58	Dec 58

"Absolute" thresholds may be lowered with practice. The nature of these changes and their extent may be altered by changing motivation and feedback. Studies will be conducted using different kinds of practice (e.g., practice in detection near "threshold," progressively increasing in difficulty) and using a different kind of feedback (a display by which the subject can constantly monitor the stimulus). Pulsed tones will also be used as stimuli.

b. GSR Studies	Loeb	Sep 58	Jun 59

GSR measurements will be made at or below levels of auditory stimuli which elicit correct verbal responses at only a chance level. This should yield some insight into the nature of GSR audiometry, as well as some insight into the relation between instrumental and autonomic-conditioned responses. Similar studies may later be performed using animals.

Subtask 4: Auditory Monitoring

Title	Experimenter	Date Started	Estimated Completion Date
a. Physical and Temporal Characteristics Influencing Performance on Auditory Monitoring Tasks	Loeb	Jul 58	Jun 59

In a fashion similar to studies on visual monitoring, subjects will be required to monitor pure tones differing in intensity, frequency, spatial origin, and temporal patterning, and to respond differentially to them. The relationships of these variables to reaction times and detection probabilities will be determined.

TASK II--Determination of Effects of Physical Environment on Performance

Subtask 1: Effects of Heat and Cold on Performance

Title	Experimenter	Date Started	Estimated Completion Date
a. Behavioral Effects of Cold Adaptation in the Rat	Carlton Marks	Jul 56	Completed

White rats working at a low ambient temperature were trained to depress a lever to receive brief periods of heat as the reinforcement. When their response rate had stabilized, the animals' living cages were moved into a 2°-C environment. The effects of this continual cold exposure were increases in both lever pressing and food intake, and a loss in body weight. The results have been published in USAMRL Report No. 325.

b. Effects of Temperature Stress Upon Performance of Certain Tracking Tasks	Newton	Jan 56	Completed

In a compensatory tracking task, pressure and movement controls interacted with low ambient temperatures only when individual differences among subjects were considered. The results have been published in USAMRL Report No. 324.

c. A Survey of An Arctic Environment	Fletcher	Jun 58	Oct 58

A general survey is being conducted in Greenland to determine what acoustical and auditory problems are peculiar to the Arctic environment.

Title	Experimenter	Date Started	Estimated Completion Date
d. Localization of Sound on Ice and Snow	Fletcher	Nov 57	May 58

A report is in press detailing the influence of surface (ice and snow) on the ability to localize the direction of sound.

e. Neural Correlates of Thermal Sensations (DA-49-007-MD-683)	Kenshalo Nafe Fla State U	Dec 55	Aug 59

This is a program of research upon the neural correlates of common sensation, including pressure and thermal sensations but excluding pain for the moment. A test is being made of the adequacy of the hypothesis that movement of tissue in which the nerve fibers lie, or compression of nerve fibers, is adequate to stimulate; and that the afferent fibers involved show no other differences under stimulation in their responding or in their failing to respond. Most recent work has been concentrated on Nafe's vascular theory of thermal sensitivity.

Subtask 2: Effects of Vibration on Performance

Title	Experimenter	Date Started	Estimated Completion Date
a. Median Lethal Time and Pathology as Dependent on Frequency of Whole-Body Vibration	Link Schaefer Yost	Aug 57	Aug 58

Young hooded and albino rats are being vibrated at frequencies ranging from 15 to 45 cycles per second until death results, displacement always being held constant at .25 inch. Immediately following death the animals are necropsied and examined both grossly and microscopically for pathological changes. Sex differences are also being investigated, and the effects of varying displacement will also be studied.

b. Effects of Relatively Severe Whole-Body Vibration on Behavior	Jacobs	Oct 57	Dec 58

The possibility that vibration may cause significant performance decrement is being studied in a number of standard rat experiments. The research is being programmed in such a way as to include behaviors dependent upon a wide range of general psychological variables, as motivation, learning, neuromuscular coordination, retention, discrimination, etc. Present investigations include work on avoidance learning, discrimination learning, and elevated maze, straight-alley, and open-field behavior.

c. Effects of Relatively Severe Whole-Body Vibration on Metabolic and Other Physiological Variables	Farrar Link Schaefer	Sep 57	Dec 58

The possibility that vibration may cause temporary or enduring physiological changes is being investigated. Studies are in progress on the effects of vibration on body weight, food and water metabolism, tissue respiration, and blood-sugar level. Further work will be programmed as required to discover the factors underlying any differences which may be obtained. Also planned are a series of experiments designed to determine the similarity between vibration and the general class of variables known as stressor agents.

d. The Effect of Low Frequency, High Amplitude, Whole-Body Vibration on Human Performance (DA-49-007-MD-797)	Schmitz Bostrom Res Lab Milwaukee, Wis.	Apr 57	Jun 59

Two sets of five human subjects each have been subjected to vibrations of 2.5 cps and of 3.5 cps with an amplitude of 0.5 inch. Measures of performance were taken before, at intervals during and after the two vibration conditions and the control condition. Re-

sults so far show trends toward decrement in performance in hand reaction time; body sway; depth perception; visual acuity; tracking; and foot pressure constancy. No decrement was found for tapping rate; hand tremor; mental addition; or foot reaction time. It is planned to study an additional twenty subjects on those variables which seem worth further exploration.

TASK III--Investigation of Vision and Perception in Relation to Performance

Subtask 1: Determination of Form and Depth in Visual Perception

Title	Experimenter	Date Started	Estimated Completion Date
a. The Perceptual Interrelation of Frontal and Stereopsis Extents in the Determination of Form	Gogel	Aug 57	Completed

The experimental aspect of this work has been completed and published as USAMRL Laboratory Report No. 331, "The Perception of Shape from Binocular Disparity Cues."

b. The Perceptual Interrelation of Frontal and Stereopsis Extents in the Determination of Perceived Depth	Gogel	Dec 56	Completed

The experimental aspect of this work has been completed and will be published as USAMRL Laboratory Report entitled, "Apparent Depth Duplication with Binocular Disparity Cues."

c. The Perceptual Interrelation of Frontal and Depth Extents	Gogel	Dec 56	Dec 58

Some theoretical and experimental consequences of considering frontal and depth extents as being perceptually interrelated have been determined for binocular disparity cues of depth. The mathematical development of this approach is continuing and it is expected that it will be applied to one or more additional cue systems with the objective of specifying perceived depth in increasingly complex visual situations. It is expected that further experimental tests of the predictive ability of this formulation will be made.

d. The Relation Between Convergence and Perceived Distance	Gogel	Dec 57	Dec 58

The problem being investigated is whether convergence can act as an effective cue to perceived absolute distance. A monocularly observed, visual field is used as a yardstick against which the subject can judge the apparent distance position of the binocularly observed object or objects. Only a few of 12 subjects showed any substantial decrease in perceived distance with an increase in convergence when a single binocular object was used. The results from using two binocular objects simultaneously suggest that the relation between perceived distance and convergence is not always independent of the position of one binocular object with respect to the other. The consequence of these results for the perception of binocular visual space will be considered.

e. Effect of Noise on the Perception of Forms in Electro-Visual Display (DA-49-007-MD-536)	Crook Tufts U.	Apr 54	Sep 58

Five more experiments in this series have been completed, the results of which are still under analysis. One study--designed to throw light on the relative importance of reduced contrast and degradation of contour for the impairment of form recognition under visual noise--indicated that when contour degradation was eliminated, scores deteriorated rapidly with decreasing contrast; when contour degradation was added, scores deteriorated much more rapidly. Other studies were concerned with the effect of the degree of familiarization on recognition of irregular forms under noise. Testing for actual recognition performance under noise has not been completed. A final report on the entire contract study is expected in late 1958.

Subtask 2: The Use of Optical Aids to Improve Visual Perception

Title	Experimenter	Date Started	Estimated Completion Date
a. The Influence of Lack of Collimation and Eyepiece Defocusing Upon Stereoscopic and Vernier Acuity	Harker	Mar 56	Jan 59

This project has been held in abeyance due to absence of personnel from the laboratory. Experimental results are being prepared as a laboratory report and additional experimentation is being initiated to measure by direct means the cyclo-torsional rotation of the eyes as a possible explanation of the observed phenomenon.

b. Response of an Observer to a Uniformly Illuminated, Unstructured Visual Field	Harker	Apr 56	Completed

The observational and bibliographic aspects of the project have been completed and prepared as Laboratory Report 343, "Whiteout--A Bibliographical Survey." No additional work specifically on this topic is contemplated.

c. Some Perceptual and Physiological Aspects of Uniform Visual Stimulation (DA-49-007-MD-866)	Cohen U of Buffalo	Jul 57	Jun 59

The study is primarily concerned with the "white-out" effect. This phenomenon involves a temporary cessation of the sense of vision during prolonged exposure to a uniform visual field. The variables studied were: (1) intensity of illumination, (2) duration of stimulation, (3) monocular and binocular vision, (4) individual differences in susceptibility to "white-out," (5) EEG correlates of "white-out." The chief findings were as follows: (1) the types of phenomena reported by subjects exposed to uniform binocular stimulation were essentially similar to those reported for monocular stimulation; (2) under both monocular and binocular conditions, subjects reported a temporary cessation of the sense of vision after prolonged exposure to a uniform field; (3) the "white-out" effect was facilitated by extensive prior stimulation; (4) such factors as blinking and eye movement as well as the presence of an object in the field tended to suppress the "white-out" effect; (5) those subjects exhibiting a low percentage of alpha activity; (6) during uniform stimulation, reports of the "white-out" effect were associated with bursts of alpha activity.

Subtask 3: Fluctuations in Visual Stimuli or in Visual Acuity

Title	Experimenter	Date Started	Estimated Completion Date
a. Perception of Continuous, Fluctuating Stimuli	Gardner	May 56	Completed

This study has been terminated with the completion of Army service of its principal investigator. The research conducted resulted in the laboratory publication #328, "Perception of Relative Frequency as A Function of the Number of Stimulus and Response Categories." The apparatus has been transferred to the Quartermaster R & D Laboratories at Natick, Massachusetts for the use there by the principal investigator in his civilian capacity.

b. Spectral Sensitivity of Small Retinal Areas (DA-49-007-MD-being negotiated)	Riggs Brown University	Jul 58	Continuing

The purpose of this study is to examine the effects of small spots of light presented parafoveally. By means of the stopped image technique it will be possible to nullify the effects of the eye movements on retinal image motion and to repetitively stimulate the same retinal area. Additionally, spots of white light may be presented to different locations on the retina to determine variations in the form of the spectral response curves or the indicated nature of different types of cone receptors.

Title	Experimenter	Date Started	Estimated Completion Date
c. Fluctuations in Night Visual Acuity (DA-49-007-MD-871)	Johnson Colby College	Jun 57	Aug 59

The study is intended to reveal the character and extent of fluctuations in night visual acuity. Fifty men are being given instruction in the use of the eyes at night and practice in viewing visual targets at scotopic levels of illumination. Following this training, each subject undergoes one or more two-hour periods of testing during which the level of visual performance is continuously delineated in terms of a performance measure. Testing consists of requiring the subject to make manual adjustive movements in response to visually perceived movements of the target. Target-distance is automatically adjusted to a level at which S is able to remain "on target" 50% of the time. Target-distance, as recorded on a kymograph, may be expected to reflect directly changes in S's visual acuity. A routine examination of the day-vision of the subjects is being carried out in conjunction with this study.

d. Psychophysiology of Perception (DA-49-007-MD-722)	Lindsley U of Calif.	Sep 56	Aug 61

Research to date has centered around the temporal factors in visual perception. Stimulus duration required for perception and a new concept called perception time have been dealt with. The total period of time required for a perceptual process to consolidate itself has been determined by methodology worked out in this study. A survey of methods for recording and analyzing evoked potentials in human subjects was made and a satisfactory inexpensive procedure involving producing a large number of oscillograms and plotting the results algebraically has been devised. This procedure has permitted the measure of latency, duration, and form of the potentials which are required to interpret the perceptual process temporally.

TASK IV--Investigation of Motion and Balance in Relation to Performance

Subtask 1: Vestibular Reactions

Title	Experimenter	Date Started	Estimated Completion Date
a. Adaptation Effects in Vestibular Reactions	Guedry Cramer Cunat	Jul 56	Continuing

Three experiments have been completed (cf. USAMRL Report No. 338), one is in progress, and another is anticipated. Results obtained point out (1) limits of stimulation beyond which the theoretical mechanics of the vestibular structures will lead to very inaccurate predictions of human reactions, (2) sufficient conditions for systematic departures from predictions, and (3) the direction and magnitude of these departures. The study in progress is concerned with further definition of the necessary and sufficient conditions for the adaptation effects which lead to these inaccurate predictions.

b. Neurophysiological Study of Apparent Adaptation Effects	Cramer Guedry	Jun 58	Continuing

Exploratory experiments have been carried out on this problem. It is hoped that it will be possible by electrophysiological methods applied to various animals to ascertain the locus and neurophysiological mechanisms involved in the apparent adaptation effects demonstrated in human subjective reactions.

c. Interactions of the Vestibular Nuclei	Cramer Guedry Dowd	Aug 58	Continuing

Responses to electrical stimulation of the different vestibular nuclei are being recorded in the stimulated and in other nuclei. Experimental variables are: intensity and duration of single-shock stimuli, duration of repetitive-shock stimuli, and interruption of connecting pathways.

Title	Experimenter	Date Started	Estimated Completion Date
d. Habituation to Angular and Linear Accelerations	Guedry Cramer & others	Aug 58	Continuing

Animals and, in some experiments, human subjects will be repeatedly exposed to angular and linear accelerations. After this conditioning period, their ability to withstand insults to the vestibular system, including (1) stimulation sufficient to produce motion sickness and (2) surgical insult to the vestibular system, will be compared with the same abilities in subjects which have not received the conditioning period.

Subtask 2: Methodological Studies of Rotation and Acceleration

Title	Experimenter	Date Started	Estimated Completion Date
a. Techniques for Studying Postural Effects of Angular Accelerations	Guedry Caldwell Cramer	Oct 58	Continuing

The vestibular system in conjunction with other response systems influences the resting tonic activity as well as compensatory activity of a large number of muscles. Angular acceleration produces a disturbance in vestibular equilibrium which, among other effects, produces compensatory postural adjustments. It is desirable to have sensitive measurement of these compensatory adjustments (1) to determine possible subtle influence on psychomotor performance and (2) to provide an index of the vestibular reaction which would possibly provide a continuous quantitative measure of the reaction throughout its course. Commencement of research on this topic has been delayed due to the concentration of effort on other topics.

b. Development of Techniques for Obtaining Continuous Estimates of Subjective Velocity Throughout the Course of Vestibular Reactions	Guedry Cramer Zitani	May 57	Continuing

A method was selected, after experimentation with a number of alternatives, to provide estimates of the intensity of the subjective reaction to angular acceleration. The method selected involves subjective estimates of angular displacement. An experiment has been completed with this method. Results indicate (1) that the method is feasible, (2) that the intensity of the subjective reaction follows the predictions of vestibular theory within certain time limits, (3) that the method may involve certain artifacts which can be eliminated by changes in procedure. A study specifically designed to detect and provide means of eliminating artifacts in this method is planned. The method will then be used to determine the "upper physiological limits" of the system and to determine differences in sensitivity with different positions of the head with respect to the axis of rotation.

Subtask 3: Preventive Measures for Undesirable Reactions Resulting From Linear and Angular Acceleration

Title	Experimenter	Date Started	Estimated Completion Date
a. Influence of an Antihistamine on the Intensity of the Vestibular Reaction System to Controlled Stimuli	Guedry Cramer	Aug 58	Mar 59

Drugs will be administered to investigate already established characteristics of the vestibular reaction, e.g., subjective velocity and nystagmic eye movements, during a variety of stimulus conditions. Some of these stimulus conditions involve changes in the position of the head relative to the axis of rotation.

b. Influence of Motion Sickness Preventive Drugs on Psychological Factors Involved in the Performance of Various Military Duties	Cramer others	Sep 56	Sep 58

This study involved the use of two motion-sickness-preventive drugs, one predicted to have slight side effects and one predicted to have strong side efects, and a placebo. Attention was focused on three issues: (1) the importance of time intervals after ingestion of the drugs, (2) the side effects of the drugs, (3) the interaction between the side effects of the drugs and the time interval. This experiment has been completed and the data are being processed.

TASK V--Improvement of Control and Coordination in Complex Performance

Subtask 1: Control and Coordination in Vehicle Driving

Title	Experimenter	Date Started	Estimated Completion Date
a. Development in Driving Skill as A Function of Cumulative Environmental Stresses	Herbert Hartman Jaynes	Jul 56	Jul 58

A battery of tests was designed to measure different response patterns important to vehicle driving. Subjects were then subjected to varying hours of driving on a cross-country fatigue course after which they were tested with the battery. The resulting data have been re-analyzed and interpreted in terms of skill decrement. Rewriting has been completed.

b. Decrement in Driving Skill Associated With Increasing Time of Exposure to Environmental Stresses	Herbert Jaynes Caldwell	Sep 57	Continuing

Research work now in progress generally follows earlier experimental design. Major revisions are (1) employing a different combination of hours of cross-country driving, (2) including a control group (no cross-country driving between pre- and post-test) for each "fatigue" group, (3) use of more tests in the driving test battery, (4) inclusion of a number of fatigue-route measures which will be recorded throughout the driving day.

Four new tests have been designed and added to the original test battery. New scoring techniques have been incorporated. Another addition has been the design and inclusion of a series of "fatigue-route" measures which will yield information on the narrowing of the external perceptual field, and the increasing variability of response which are postulated as a consequence of lengthening the driving period.

A number of specific vehicle-manipulation tasks have been built of concrete and asphalt as a permanent structure at Ft Knox. A lighting system is being added to allow night as well as day testing.

Subtask 2: Bio-Mechanics of Hand Controls

a. The Relation Between the Location of a Hand Control and the Maximum Forces Which Can Be Exerted	Caldwell	Sep 56	Sep 58

An investigation of hand-control location relative to the maximum force which can be imposed upon it has been completed. The variables of control elevation, lateral position, and distance from operator were evaluated for their influence on force generation. Control distance appears to be the major factor in influencing the operator effort. A report is now being written.

b. The Effect of Various Body Supports on the Strength of Linear Hand Movements	Caldwell	Sep 57	Continuing

A study now in progress attempts to determine the effect of elbow angle on the strength of the push movement, and to examine the extent to which this effect is dependent upon the height of the back-support.

c. The Influence of Control-Grip Angle on the Performance of a Manual Position Task	Herbert	Mar 57	Jun 58

Eighteen right-handed males guided a probe through a metal tube without making contact. Six tubes were positioned so as to require some one of six different directions of arm movement from trial to trial. The handle of the probe could be altered so that the angle between probe and handle could be set at 75°, 90°, or 105°. A report is in preparation.

Title	Experimenter	Date Started	Estimated Completion Date
Subtask 3: Sensory Cues and Motor Performance			
a. The Judgment of Angular Positions in the Horizontal Plane on the Basis of Kinesthetic and Visual Cues Alone and in Combination	Herbert Caldwell	Jun 57	Jul 58

Twenty-one subjects judged the location of angular positions from 0° to 90° in the horizontal plane. Three cue conditions were presented: (1) kinesthetic only, in which the subject wore a blindfold and moved his arm to a designated angular position; (2) vision only, where the subject, without blindfold and with hands in light, directed the experimenter in positioning a long, luminous pointer; and (3) kinesthetic-plus-vision, in which the subject was allowed to position his arm while viewing a luminous pointer which showed the position of the arm.

b. Analysis of Abductive and Adductive Phases of Movement in Continuous Tracking	Hartman Herbert Jaynes	Jun 57	Dec 57

The tracking moves of right-handed and left-handed subjects were analyzed. No differences were found between the abductive and the adductive phases of movements. USAMRL Report No. 314 describes the data.

c. The Effect of Joystick Mass on Tracking Performance	Hartman	May 57	Dec 58

The study was concerned with the effect of mass of the control (moment of inertia) on performance. The joystick handles weighed 1 oz., 8 oz., 16 oz., 24 oz., 32 oz., and 40 ounces. The optimal stick length (18 in.) was used. Two conditions of sensitivity were used--the best had a sensitivity ratio of 2.85:1, and the worst had a sensitivity ratio of 0.5:1. The study is designed to answer two questions: First, what is the effect of control mass on accuracy of tracking? Second, is that effect different for large tracking movements than it is for small tracking movements? Data are being analyzed.

d. Certain Physiological Correlates of Psychomotor Functioning (DA-49-007-MD-620)	Malmo McGill U.	Jun 55	Continuing

Chief findings in this continuing study were as follows: (1) tracking under conditions of sleep deprivation is chiefly associated with progressively increasing physiological activation during the vigil; (2) during qualitatively different stimulus situations (and also under varying degrees of activation in the same situation) individuals exhibited characteristic patterns of somatic and autonomic response. That is, individual differences were found which were highly consistent from situation to situation; (3) arousal level (as determined by a combined EEG and EMG index) was positively correlated with magnitude, and negatively correlated with habituation rate of EMG after-responses. In addition, progress was reported on the construction of a new tracking apparatus and a continuous amplitude/time for integrating electroencephalographic (EEG) frequencies in the beta range.

e. Sensing Mechanisms and Control of Fine Movements in Perception, Motor Precision, and Performance (DA-49-007-MD-625)	Girden Brooklyn College	Jun 55	Aug 58

Precision of performance was measured for a range of sensitivities of a rotational pressure control in pursuit tracking of one dimensional moving target. Completed experiments have assessed the extremely sensitive controls and also the adjacent range of medium sensitivities. Tests of the entire range of force requirements are to be completed by August 1958. Final report is expected about October 1958.

Subtask 4: Complex Behavior

	Title	Experimenter	Date Started	Estimated Completion Date
a.	The Reliability of a Magnitude Estimation Scale	Alluisi	Jan 58	Sep 58

A study has been completed on assessing the reliability of a magnitude-estimation scaling technique in the construction of both a ratio and a category scale of judgments of line lengths. Data have been analyzed and a report is being written.

	Title	Experimenter	Date Started	Estimated Completion Date
b.	Factors Influencing Complex Decision-Making Behavior (DA-49-007-MD-537)	Henneman U of Virginia	May 54	May 59

Currently, attention is being focused on an analysis of the factors influencing retention in tasks in which the subject's response is in part derived from remembered or "stored" information. The "storage load" of a human operator represents the many different conditions under which he may receive information and terminate a series of events. Experimental analysis of "storage load" will make it possible to evaluate complex tasks in terms of their "storage load;" to minimize task errors in complex situations; and to determine the "storage load" (capacities) of different human operators. Further studies in this series will be concerned with the conditions under which the presence of irrelevant data interferes with speed and accuracy of performance.

Subtask 5: Theoretical and Methodological Investigations

	Title	Experimenter	Date Started	Estimated Completion Date
a.	A Manual for Statistical Computations	Jaynes	Dec 56	Continuing

This manual will provide formats for the tabling of experimental data and simple computational directions for common statistical analyses based on such tables. Notation will demand nothing more than a knowledge of high school algebra. A section dealing with some useful wiring plans for the IBM 602-A and 604 calculating punches will also be included. Comments on experimental design and interpretation of results will be provided for the more sophisticated reader.

	Title	Experimenter	Date Started	Estimated Completion Date
b.	Context Effects in Psychophysical Judgments (DA-49-007-MD-877)	Kappauf U of Illinois	Jul 57	Aug 59

The purpose of this study is to determine the extent to which context effects may be reduced by choice of the psychophysical method being used and by the time interval between trials. Work so far has been limited to literature review; development of experimental apparatus; and the testing of subjects in a series of preliminary explorations of method and variables.

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CURRENT PROJECTS

A. SUPPORTING RESEARCH ACTIVITIES

Project	Experimenters	Date Started	Estimated Completion
1. Effects of K Agents on Simulated Driving	R. E. Jelinek Lt. J. Keys	Sept 57	July 58

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This is a cooperative research study, between the Human Engineering Laboratory and the Army Chemical Center, designed to investigate the effects of K agents on complex psychomotor performance.

Project	Experimenters	Date Started	Estimated Completion
2. Physiological and Psychological Effects of Mozzle and Breech Blast.	J. J. Romba	Aug 55	Continuing

This program was initiated to determine the effects of blast parameters on various types of performance. Because of the obvious hazards involved the program was initiated on an animal level.

Currently normative data are being collected on a group of 12 animals scheduled for exposure during August 1958. The performance measures of primary interest are: learning retention, relearning, locomotion, interest, general appetite and auditions. Animals will be initially exposed to a level of 5-7 PSI. Depending on the results this level will be increased.

3. Some Determinants of Vigilance Behavior	J. Dardano I. Mower	Jan 58	Aug 58

This study is oriented toward specifying in greater detail characteristics of individuals required to perform prolonged monitoring by correlating a measure of arousal (GSR) with detection of and response time to aperiodic stimulus presentation.

4. Human Capacity for Work Output	S. A. Hicks	Nov 57	Aug 58

Questions often arise regarding the expected work output of individuals using various types of control devices or equipment under various climatic conditions. A literature review was initiated in an attempt to integrate the available information on these topics and also to provide areas of needed research.

5. An Evaluation of Impulse vs. Continuous Noise on Hearing Loss	R. Donley	Jul 58	Sept 58

This is an evaluation of audiograms collected over a period of time on groups of individuals who in their normal work are exposed to either continuous noise or impulse type noise such as occurs in firing various types of weapons.

6. An Evaluation of Methods for Presenting Height Information to Radar Operators	J. R. Erickson C. Fried	Jul 58	Oct 58

Height determination of aircraft targets is becoming increasingly more important in the evaluation of tactical threat. Various methods have been proposed for displaying height information such as encoded symbols, height categories etc. This study will evaluate the various methods from the standpoint of operator efficiency.

7. Sound Pressure Levels for Hand Held Weapons	R. E. Jelinek R. Donley	Jun 58	Continuing

This project has as its goal the compilation of sound pressure levels for hand held weapons. A compilation of this type will be useful in the cross comparison of weapons with respect to evaluating the requirements for ear protection on current and future hand held weapons.

8. Development of Radar Simulation Equipment	J. I. Randall J. A. Stephens E. C. Weiss	May 56	Continuing

The goal of this development program is to provide a master facility which in addition to its importance as a research tool, will be capable of evaluating critical human factors problems of current or proposed radar systems.

One phase of the electronic system, which is capable of displaying sine wave derived symbols, has been completed. Current efforts are directed toward generating a number of moving targets.

B. SYSTEMS EVALUATION ACTIVITIES

The details of the various systems listed below are classified from CONFIDENTIAL to SECRET. These projects represent a continuing effort to provide developing agencies with the necessary specific human factors information to insure operational efficiency of the fully developed systems.

This type of activity demands that project personnel become thoroughly familiar with the military characteristics and the tactical situations envisioned for the system. Following this, detailed consultations are held with design personnel to insure proper cognizance of human factors requirements in the design of the system. In many cases supporting research is conducted to solve human engineering problems. An evaluation of component items is performed as soon as the items are available in order to discover any deficiencies. Each of these programs will culminate in an evaluation of the complete operational system under field conditions. Some of the main factors taken into consideration are:

a. Reduction of error-likely situations encountered in the assembly of the unit, handling of component items, checkout procedures, and possible user abuse of equipment.
b. The efficiency with which trained operators can set up and use the equipment.
c. Ease of maintenance.
d. Environmental factors which might affect the efficiency of the system.
e. Deriving detailed standard operating procedures for the system.

The following weapon systems are included in this program:

1. DART	J. Torre R. Gschwind	Continuing
2. JUPITER	E. C. Weiss W. Wokoun	Continuing
3. L.A.A. Weapon System	C. N. McCain M. Schneider	Continuing
4. LACROSSE	B. Sova R. Lazar	Continuing
5. Light Antitank Weapon (L.A.W.)	H. Curran G. Chaikin	Continuing
6. PERSHING	W. Wokoun G. Molar	Continuing
7. RED EYE	R. Karsh G. Chaikin	Continuing
8. REDSTONE	W. Wokoun G. Molar	Continuing
9. SERGEANT	M. Schneider G. Molar	Continuing

C. INFORMATION DISSEMINATION — L. Ivey — Continuing

To keep Ordnance engineers abreast of the rapid advances made in human engineering, an activity was created which has the responsibility of disseminating valid human engineering design criteria to Ordnance engineers in a form that is practical and understandable. Even the most engaging and promising work can remain unused unless read and digested by those who plan and develop equipment. Proper emphasis on pertinent material illustrations, photographic layouts, and other publication techniques is employed for best results. Two publications are published regularly, a "Data Report" and a "Newsletter."

D. FIELD LIAISON ACTIVITIES — Team Leaders: C. D. Congleton, G. R. Garinther — Continuing

The purpose of this program is to gather human engineering data pertinent to Ordnance materiel assigned to combat organizations. The data are gathered from militar-- personnel

through questionnaires, interviews, monitoring maneuvers, and other means which lend themselves to this problem. The data obtained through this program are evaluated by the Human Engineering Laboratory and reduced to design criteria which are disseminated to Ordnance design arsenals or other interested Department of Defense agencies.

Current surveys include:

a. Atomic checkout procedures
b. Cable and cable connector problems for Guided Missiles

BIBLIOGRAPHY OF PUBLISHED REPORTS SINCE LAST CONFERENCE

Report No. 1-57-1 (C) — A Human Engineering Evaluation of the REDSTONE Missile. E. C. Weiss

Report No. 1-58-1 (C) — A Human Engineering Evaluation of the JUPITER Missile System: Lighting Specifications. E. C. Weiss - L. M. Feldman

Report No. 1-58-2 (U) — A Human Engineering Evaluation of the JUPITER Missile System: Cable Laying. E. C. Weiss - L. M. Feldman

Report No. 2-58-1 — A Human Engineering Evaluation of the REDSTONE Missile System: The Azimuth Laying System. W. Wokoun - E. C. Weiss

Report No. 2-58-2 (U) — A Human Engineering Evaluation of the REDSTONE Missile System: The Firing Data Computer Truck. E. C. Weiss - L. M. Feldman

TM No. 10-57 (U) — Human Engineering Problems of the Armored Personnel Carriers T113 and T117. Albert S. Bacon, Donald R. Cronk, Anthony J. Rose.

TM No. 1-58 (U) — An Investigation of Symbol Meaning Combinations for Use in Radar Displays. James P. Torre - Leonard A. Sanders

TM No. 2-58 (U) — Evaluation of Radar Symbols for Target Identification. Joseph F. Dardano - Ray Donley with Technical Assistance of Harold T. Curran.

TN No. 3-58 (C) — Human Engineering Evaluation of the LACROSSE Assembly Area and Launch Area--Task III Missile, Launcher Series 3000--Lewis Estrine - Bruno L. Sova.

TM No. 4-58 (U) — Discriminability of AAOC Symbols. J. F. Dardano - J. A. Stephens with Technical Assistance of H. T. Curran, L. Sanders and O. C. Wolfe

TM No. 5-58 (U) — An Evaluation of 50 & 80LB Ammunition Containers and Recommendations for Improved Package Design. Samuel A. Hicks - Claude N. McCain

TM No. 6-58 (U) — Some Effects of Noise on Human Behavior. Nathan H. Azrin

TM No. 7-58 (U) — A Dynamic Human Engineering Evaluation of the Armored Personnel Carriers T113-T117. G. R. Garinther - J. Torre - J. E. Tiernan and D. E. Holzen.

TM No. 8-58 (C) — A Human Engineering Review of Special Weapons Stock Pile to Target Sequence. C. D. Congleton - F. W. Smith and W. H. Bozinger

II. ORDNANCE WEAPONS COMMAND

VITA

Lorenzen, Theodore G. Jr., Ordnance Engineer, BS, Bradley University, 1951

CURRENT PROJECTS

The Headquarters Ordnance Weapons Command, coordinates the human engineering program on all mission items. Analysis and evaluation of development materiel is performed at the member Arsenals assigned development support responsibility.

A continuing program of reviewing projects and technical reports concerning development items and a constant search of new literature is being carried on in order to assist the project engineers on human factors problems.

Major emphasis during the past year has been concerned with the VIGILANTE (U) System, by assisting the Human Engineering Laboratory and the System Contractor in the analysis and solution of problems associated with the development of the system.

Numerous requests for human factors data on blast levels at crew positions of weapons equipped with and without blast deflectors have been received and processed. Information on blast levels is being gathered by the Human Engineering Laboratory on items under test at Aberdeen Proving Ground.

III. ORDNANCE TANK-AUTOMOTIVE COMMAND

VITAE

Hansen, Alfred A. E., Human Factors Consultant, Special Engineering Branch, Research & Development Division

Carney, William H., Coordinator, Design Branch, Engineering Division

Huber, Roy L., Automotive Research & Design Engineer, Special Engineering Branch, Research & Development Division

CURRENT PROJECTS

1. Super Mule (mock-up) at Detroit Arsenal, Center Line, Michigan
2. Air-Transportable Armored Multi-Purpose Vehicle T116 (mock-up) at Pacific Car & Foundry Company, Renton, Washington
3. Tank, Airborne 76mm Gun T92 at Automotive Branch, Aberdeen Proving Ground, Maryland
4. Air-Transportable Armored Multi-Purpose Vehicles T113E1 and T113E2, Drawing analysis, at Detroit Arsenal, Center Line, Michigan
5. Recovery Vehicle, Medium T-88, at Aberdeen Proving Ground, Maryland
6. Air-Transportable Armored Multi-Purpose Vehicle T113, at Food Machinery and Chemical Corporation, San Jose, California
7. Air-Transportable, VIGILANTE Vehicle design analysis, at Food Machinery and Chemical Corporation, San Jose, California
8. A one hundred and fifty (150) page Human Factors and Data Booklet pertaining to military vehicles, to serve as a guidance to project engineers on military vehicles, will be published by this Command sometime in June.

IV. PICATINNY ARSENAL

VITAE

Goldsmith, C. T., Head, Human Engineering Unit, MA, Fordham University

Seminara, J. L., Psychologist, MA, New York University

Strauss, P. S., Psychologist, MA, New York University

Worms, P. F., Psychologist, MS, City College of New York

Wright, N. L., Psychologist, MA, Fordham University

CURRENT PROJECTS

Several types of Human Factors tasks are presently underway in the Feltman Research and Engineering Laboratories:

1. Systems Design

Human Factors Specialists are currently working as a member of the "design team" for the warheads phases of the following Atomic Projects:

a. XM75 - NIKE HERCULES
b. XM84 - LACROSSE
c. XM86 - HONEST JOHN
d. XM90 - HAWK
e. HM91 - SERGEANT
f. XM - NIKE ZEUS

The participation in team design efforts extends also to the DAVY CROCKETT Project and other classified items.

Human Factors areas considered include:

a. Analysis of tasks
b. Personnel requirements
c. Training requirements
d. Manuals and check sheets
e. Test equipment
f. Handling equipment
g. Packing
h. Assembly
i. Work Space Layout
j. Maintenance
k. Pre-and-In-Flight Activities
l. System synthesis

The methods used are both analytical and empirical, and the results consist of detailed design recommendations for the consideration of, and implementation by, the project manager.

2. Supporting Research

a. Radioactive Illuminants. Having established the feasibility of utilizing self-luminous material to light Ordnance information displays, research in this area continues in order to specify optimum colors, brightnesses, character sizes and designs.

b. Control/Display Ratio. An investigation to determine optimum C/D ratio, torque, and control size for setting information into devices is underway.

c. Effect of Battle Stress. A comprehensive literature survey, aimed at collecting information on the effects of battle stress on performance with Ordnance equipment is underway.

3. <u>Ad Hoc Studies</u>

Empirical investigations aimed at evaluating specific pieces of equipment. Currently underway are studies of:

a. Optimum location, type and design for multi-position fuze selector switches.

b. An analytic and experimental evaluation of several hand-held weapon systems.

4. <u>Systems Analysis</u>

Studies which, although they may include an experimental phase, are primarily analytical in nature.

a. An evaluation of the nature and extent of human errors in artillery accuracy in relation to all other system errors.

b. A study of the effectiveness of anti-personnel mine fields in relation to distribution and visual detectability of mines.

5. <u>Miscellaneous Activities</u>

a. <u>Consultation</u>. Almost $\frac{1}{2}$ man/year per year is devoted to consulting with design personnel concerning optimum design of equipment.

b. <u>Field Liaison</u>. In addition to internal field information gathering tasks, a second field study of Atomic Weapons, conducted by HEL, is being monitored.

BIBLIOGRAPHY OF PUBLISHED REPORTS SINCE LAST CONFERENCE

Picatinny Arsenal Technical Reports

No. 2471 Readability Treshold of Letters and Numbers Backlighted by Radioactive Illuminants
Wright, N. L. and Seminara, J. L., May 1958

No. 2539 A Human Factors Evaluation of Metal Container Opening Devices Under Arctic Conditions
Strauss, P. S. and Worms, P. F. In Press

No. 2551 An investigation of the Maximum Allowable Torque for Rotary Selector Knobs.
Worms, P. F. and Goldsmith, C. T. In Press.

Engineering Research Laboratory Technical Memos.

No. 109 A Human Factors Evaluation of the XM289 and XM386 Launchers in relation to the XM86 Adaption Kit for the XM50 HONEST JOHN ROCKET. (U)
Seminara, J. L. April 1958. Report CONFIDENTIAL.

No. 112 Human Factors Recommendations for a Carry Device for NIBLICK Ammunition. (U).
Strauss, P. S. May 1958 Report SECRET, Special Handling.

No. 117 An Investigation of a Simulated "Stress" Condition.
Worms, P. F. May 1958.

No. 118 Preliminary Report on the Visual Detection of Fluorescent Colors.
Wright, N. L. and Goldsmith, C. T. May 1958.

In Press Phase I. Human Factors Research Program to Determine the Optimum Multi-Position Fuze Selector for Artillery Rounds.
Seminara, J. L. and Worms, P. F.

In Press A study of Legibility Concerning the Interaction of Letter Design with the Color and Brightness of Transillumination.
Wright, N. L.

V. WATERTOWN ARSENAL

VITA

Ernst, Harry W., Acting Deputy Chief, R&D Division

CURRENT PROJECTS

Human factors studies conducted in the design of the XM33 Launcher and VIGILANTE projects.

VI. U. S. ARMY ORDNANCE ARSENAL, WATERVLIET, WATERVLIET, NEW YORK

VITA

DeTogni, G. R., Ordnance Engineer (Human Factors), B.S. in Physics, Union College, 1951

CURRENT PROJECTS

Project	Experimenter	Date Started	Estimated Completion Date
1. VIGILANTE	G. R. DeTogni	Jan 57	Jun 58

a. A time and motion study of the ammunition loading operation was performed, considering the speed and effort of the various possible motion patterns. Standard data plus time estimates were used to determine the overall time for reloading under normal and emergency conditions. Results were coordinated with the various Ordnance agencies and contractors involved in the development of this weapon system.

b. By contributing existing safety and performance standards, an optimum size, shape and weight ammunition box was mutually determined at an interagency coordination meeting.

Project	Experimenter	Date Started	Estimated Completion Date
2. Pivot-Chamber Gun	G. R. DeTogni	Apr 56	Sept 57

a. Discussion with project personnel and review of concept sketches plus proving-ground test firing were undertaken to consider the human factors involved in the application of this new weapon design to larger caliber cannon. While some operational, maintenance and safety problem areas exist due to the temporary and economic nature of the proof test components and set ups, the overall problems appear no more severe than those of conventional cannon. Many safety, operational and functional advantages are possible in larger size pivot chamber cannon.

b. Use of newly developed ammunition is being studied. Coordination with Picatinny Arsenal will be performed during proof tests to evaluate items of mutual interest.

Project	Experimenter	Date Started	Estimated Completion Date
3. Environmental Studies	G. R. DeTogni	Oct 55	Continuing

a. 81mm Mortar T64E2

The relative merit of two elevating crank knobs was evaluated by performing a time and motion analysis. Speed and effectiveness of operation, operator comfort and safety, crank-radius and torque requirements, operation with Arctic handwear, knob length-to-diameter ratio and operator dimensions were considered. Results and recommendations were submitted to cannon designers.

b. Arctic tests

Fort Churchill, Canada, engineering tests were reviewed. Among other data, a maximum time limit of five minutes was recommended for operational and maintenance tasks requiring removal of outer handwear (two pairs of gloves, outer leather and inner wool, are still worn). Arctic test films were viewed by design engineers; gloved-hand and other anthropometric data were distributed to design engineers.

BIBLIOGRAPHY OF PUBLISHED REPORTS

Quarterly Report, TR 201B, Oct 57, Environmental Tests of Cannon Components, G. R. DeTogni

Quarterly Report, TR 201B, Jan. 58, Environmental Tests of Cannon Components, G. R. DeTogni

Quarterly Report, TR 201B, Apr. 58, Environmental Tests of Cannon Components, G. R. DeTogni.

Quarterly Report, TR 201B, July 58, Climatic and Human Engineering Studies, G. R. DeTogni.

Consolidated Annual R&D Project Report, TW 4161, Environmental Tests of Cannon Components

VII. ORDNANCE CORPS, ROCK ISLAND ARSENAL

VITAE

Heidel, William, Carriage Design Engineer, BSME, Bradley University, 1951

Sharp, Harold, Launcher Design Engineer, BSME, University of Illinois, 1948

Peterson, Warren, Laboratory, BSME, Bradley University, 1932,

Freymann, Edward, General Ordnance Design Engineer

Johnson, William, Ordnance Design Engineer

CURRENT PROJECTS

1. Equipment Design (Internal)

Human engineering evaluation of the LITTLE JOHN and HONEST JOHN Rocket Launcher Systems.

2. Supporting Research (Internal)

a. Noise Abatement Project. Reducing the noise of a chain hoist on rocket launcher handling equipment. This project reduces troop detection in a night operation, which improves psychological and morale factors affecting troop performance.

b. Coated Handwheel Project. Investigation of the reduction of the thermal sensitivity of the hand by coating handwheels with plastisol and operating them in the temperature extremes.

VIII. FRANKFORD ARSENAL, PHILADELPHIA, PENNSYLVANIA

VITAE

Barron, John W., Psychology Assistant, PFC, MA, Atlanta University, 1957

Cotnam, John D., Psychology Assistant, PFC, BA, Syracuse University, 1957

Garner, Dr. Wendell R., Consultant, The Johns Hopkins University, Department of Psychology

Gibson, Dale, Psychology Assistant, PFC, BA, Denison University, 1957

Karr, A. Charles, Psychologist (Human Engineering) MA, Lehigh University, 1953

Teichner, Dr. Warren H., Consultant, University of Massachusetts, Department of Psychology

Tulencik, Joseph G., Psychology Assistant, PFC, BA, Ohio University, 1956

CURRENT PROJECTS

Project	Experimenters	Date Started	Estimated Completion
1. Tank - Tracking Study	A. Charles Karr PFC Dale Gibson	Nov 57	Jun 59

The purpose of this project is to determine the optimal joy-stick control characteristics for anti-tank weapons. To accomplish this goal, a tracking system is being developed which will simulate as closely as possible true tank-tracing problems. As presently conceived, the tracking system will permit the testing of various weapons systems and will be valuable as a training simulator.

2. Human Engineering of U-BAT Weapon	PFC Dale Gibson PFC John W. Barron	Oct 57	Jul 59

This Branch has had the human engineering responsibility for the design of the U-BAT system. Major emphasis has been on the design of the sight and the control system. Placement and design of the various components for the purpose of assuring the most efficient overall system have received considerable study. Other human factors problems with respect to man-portability, ease of maintenance, environmental problems and the like have been given due consideration during all design-development phases.

An experimental program was designed and initiated for determining the feasibility of using a joy-stick control system for this weapon. The U-BAT recoilless rifle (joy-stick-controlled) was compared with the BAT recoilless rifle (Handwheel-controlled). Moving and stationary targets were used. The tanks were simulated by standard 7-1/2' x 7-1/2' targets at ranges of 1500, 3000 and 4500 feet with velocities of 20, 25 and 30 MPH. Firing of both the spotter and the major caliber were simulated by a spot of light directed from the barrel of each weapon. A clock was mounted at the bottom of the screen. Thus, the flash on the screen from the light offered accuracy data while the clock gave an indication of time. These data were recorded for each firing of either weapon by means of a camera placed in front of the screen.

The results of this study cannot be regarded as conclusive because of the small sample (four subjects). From the data recorded, however, the joy-stick showed signs of being the superior control system. This is not to imply that the joy-stick system is optimal as it now stands. Optimal control-display ratios and force requirements have yet to be determined. A thorough program of research is required in order to determine these optimal joy-stick control characteristics with any degree of confidence. This matter is now being investigated under a separate project.

3. Development of a Memory Sight	Pfc J. Tulencik A. Charles Karr	Oct 57	Sept 59

The development of the memory sight to be used is in conjunction with spotting rifles still in its early stages. This sight incorporates a reticle with a phosphor coating that records the position of the spotting round in relation to the target and the point of aim. In this way the gunner can make corrective adjustments on the basis of the displacement of this spotter from the target as reviewed through the sight. The Engineering Psychology Branch is monitoring the development of one type of memory sight and is investigating other possible techniques.

4. Human Engineering Problems of Shoulder Fired Weapons	Pfc J. Cotnam	Sept 57	Continuing

This Branch works closely with the design engineers to uncover, study, and derive solutions for human engineering design problems for a variety of shoulder-fired recoilless weapons. In connection with one particular weapon, for example, the human engineering responsibility has been to study human factors problems, resulting from use of a new spotting system, evaluate the shoulder rest design, suggest improvements, and assist in planning operational tests.

5. Study of Spotting Techniques	Pfc J. Cotnam Pfc D. Gibson	Jul 58	Continuing

This Branch has been asked to look into the feasibility of using multiple shot spotting rounds in place of the present single shots. The intention here is to reduce the time between target acquisition and target kill. The reasoning behind this is that with an optimal number of shots and separation in range, (successive or simultaneous) the operator should be able to get on target much more rapidly. It is assumed that the multiple spotter display will provide the operator more information more quickly than can be achieved with single shots.

IX. U. S. ARMY ORDNANCE MISSILE COMMAND ARMY ROCKET & GUIDED MISSILE AGENCY, REDSTONE ARSENAL, ALABAMA

VITA

Graham, Donald I., Jr., Technical Advisor, Field Protective Measures and Human Engineering, CE degree, Northwestern University

CURRENT PROJECTS

This agency has current and continuing human factors studies involved with the following guided missile projects. In brackets are the contractors engaged on said projects and funded by this agency directly, or indirectly:

1. DART (Aerophysics Development Corp - Utica Bend Corp - HEL)
2. LACROSSE (The Martin Company - HEL)
3. SERGEANT (JPL - HEL)
4. HAWK (Raytheon Corp - Dunlap & Associates - HEL)
5. NIKE HERCULES (BTL - Douglas Aircraft Company)
6. TALOS (RCA)
7. RED EYE (Convair - HEL)
8. AAOC Radar Symbol Studies (HEL)
9. LIGHT ANTI-TANK WEAPON (Hesse-Eastern-HEL)

BIBLIOGRAPHY OF PUBLISHED REPORTS

This agency has published no reports under the ARGMA name in regard to human engineering. However, ARGMA has initiated and funded the above referenced projects which have all resulted in published reports or technical memoranda from either the HEL/APG or the contractor. The distribution of reports from one contract to the participants in another contract, where appropriate, assures broad dissemination and use of the technical data obtained.

X. OFFICE OF ORDNANCE RESEARCH, U. S. ARMY, DUKE STATION, N. C.

VITAE

Murray, James J., Director, Engineering Sciences Division, OOR

Espenschade, Park W., Chief, Environmental Branch, Engineering Science Division

XI. DIAMOND ORDNANCE FUZE LABORATORIES, WASHINGTON, D. C.

VITAE

Brown, Horace E., Jr.

Ulrich, John A., Lt Col

U. S. ARMY ORDNANCE ARMORY, SPRINGFIELD, MASSACHUSETTS

VITAE

Lizza, Albert J., Rifle & Hand Arms Design Engineer, MS (Mechanical Engineering) University of Massachusetts, 1958
Area of specialization: Ordnance Engineering

Rocha, John C., Rifle & Hand Arms Design Engineer, BS, New Bedford Institute of Technology, 1952
Area of specialization: Ordnance Engineering

CURRENT PROJECTS

1. Weapon Weight Distribution Program: A study of the effect of shoulder weapon weight distribution on the time required to get weapon on target and accuracy of shooter weapon combination. This study, being conducted by the Armory, is outlined in a memo to PP&CO dated 26 March 1958.

2. Sight Configuration Study: A study of several iron sight configurations to determine the effect on the ability of the shooter to bring the weapon rapidly on target and obtain a hit. Several types of specially designed sights are currently being fabricated for testing by the Armory.

BIBLIOGRAPHY

1. Contract DA 19-020-504-ORD-4264, a study of the effects of low level illumination on sight performance.

2. Contract DA-19-020-504-ORD-4278, a study of the relationship of the stock comb to sight line.

QUARTERMASTER RESEARCH & ENGINEERING CENTER, U. S. ARMY

NATICK, MASSACHUSETTS

I. Vitae

II. Current Studies

III. Bibliography of Published Reports

I. VITAE

Burkhalter, Thomas H., 1st Lt., QMC, Human Factors Study Group, M.A. Ohio State University, 1956. Area of specialization: Human factors problems in systems operations; engineering psychology.

Dusek, Dr. E. Ralph, Chief, Psychology Branch, Ph.D. State University of Iowa, 1951. Area of specialization: Physiological psychology; psychomotor performance.

Fine, Dr. Bernard J., Research Psychologist, Systems Research Section, Ph.D. Boston University, 1956. Area of specialization: Social psychology with emphasis on attitude change, personality and small groups.

Gardner, Dr. R. Allen, Research Psychologist, Psychophysiology Section, Ph.D. Northwestern University, 1954. Area of specialization: Perception; learning.

Gaydos, Dr. Henry F., Chief, Psychophysiology Section, Ph.D. University of Florida, 1953. Area of specialization: Tactual-kinesthetic perception; apparatus design; human engineering.

Jones, Clarke E., Research Psychologist, Human Engineering Section, M.S. Pennsylvania State University, 1949. Area of specialization: Physiological psychology.

Kobrick, Dr. John L., Chief, Human Engineering Section, Ph.D. Pennsylvania State University, 1953. Area of specialization: Engineering psychology; apparatus design; learning.

McGinnis, Dr. John M., Chief, Systems Research Section, Ph.D. Yale University, 1929. Area of specialization: Human factors components of system design; troop attitudes and preferences.

Mendenhall, Robert L., Captain, QMC, Human Factors Study Group, M.S. Oklahoma A&M College, 1956.

Newman, Dr. Russell W., Chief, Anthropology Branch, Ph.D. University of California, 1949. Area of specialization: Applied physical anthropology.

White, Robert, Physical Anthropologist, Anthropology Branch, B.S. Haverford College, 1939. Area of specialization: Applied physical anthropology.

II. CURRENT STUDIES

A. CRITICAL ENVIRONMENTAL FACTORS AND THE QM-EQUIPPED SOLDIER

Studies	Experimenters	Date Started	Date Completed
1. Speed of Response as a Function of Heat and Cold Stress on the Soldier.	H. F. Gaydos	June 58	June 59

The purpose of this investigation is to determine what effect exposure to hot or cold environment, which results in changes in the soldier's body thermoregulatory functions, will have on his reaction time for several types of responses.

Studies	Experimenters	Date Started	Date Completed
2. Performance on a Vigilance Task as a Function of Cold Stress and Other Stress Variables.	R. A. Gardner	July 58	June 59

The capacity to remain alert in order to detect low intensity stimuli in the surrounding environment is known to deteriorate with the passage of time. The purpose of these studies is to determine how such deterioration may be affected when a soldier is subject to conditions of cold stress alone and in combination with other stress variables.

Studies	Experimenters	Date Started	Date Completed
3. Studies of the Effects of Heat and Humidity on Performance of Complex Mental Tasks and Tasks Requiring Sustained Mental Concentration.	H. F. Gaydos	Aug 58	June 59

Dry bulb and wet bulb temperatures will be systematically varied in order to determine critical values at which performance on different types of mental tasks is significantly affected.

Studies	Experimenters	Date Started	Date Completed
4. Studies of the Relationship Between Personality Variables and Changes in Blood Circulation Time During Soldier Exposure to Cold.	B. J. Fine	Apr 57	Dec 59

The purpose of this series of studies is to investigate the psychophysiological concommitants of behavior under conditions of cold stress. Preliminary studies indicate that consideration of personality variables may effectively increase the precision and reliability of cold chamber studies. The results of such studies will be relevant in field studies conducted under conditions of extreme cold as well.

5. Exploratory Investigations of the Relationships Between Psychological and Anthropological Variables and Physiological Responses for Soldiers Experiencing Cold Stress.	H. F. Gaydos B. J. Fine	Mar 58	Aug 58

This is an effort to isolate some of the individual variability noted in many physiological studies conducted with soldiers experiencing cold stress. It is hypothesized that psychological and anthropological variables may account for much of this variability. In these studies an attempt will be made to determine the nature of the relationships between the relevant variables.

6. Effects of Experience with Anchor Points of a Scale on Values of Words Rated on the Scale.	B. J. Fine	Mar 58	Sept 58

In attempting to improve techniques for rating and scaling soldier responses to QM items under conditions of stress more information is needed on characteristics of variables affecting scaling procedures. This study is an attempt to assess the importance of prior rater experience with words used on a rating scale.

7. Investigation of the Effects Rater Characteristics on the Scale Values Derived from His Rating of Items.	B. J. Fine	Mar 58	Oct 58

This is an attempt to determine to what extent the rater acts as a source of bias in rating QM items on scaled questionnaires and to determine whether such bias may be controlled or removed from the scored responses.

8. Investigation of Differences in Preference Reactions of Airborne and Regular Troops.	Psychological Research Assoc. Contract	June 56	July 58

Methods previously employed to determine criteria used by Artillery, Infantry, Ordnance, Armor and Signal Corps troops in evaluating QM clothing and equipment have been applied to Airborne troops. The purpose of the study was to determine whether or not Airborne Troops use significantly different criteria in evaluating QM items for paratroopers anticipating making a combat jump.

B. STUDIES OF SOLDIER-EQUIPMENT-ENVIRONMENT SYSTEMS AND INCOMPATIBILITIES

1. Human Engineering Study of the Maintenance of QM Materials Handling Equipment.	Capt. R. L. Mendenhall	July 58	Sept 58

This study will examine the man-machine-supply system in maintenance. The purpose of the study is to identify problems which design personnel may take into account in future end item development. Specific areas to be investigated are application of sound human engineering in machine design for maintenance and the resources and supplies necessary for accomplishing maintenance.

Studies	Experimenters	Date Started	Date Completed
2. Operational Analysis of the Missile Propellant Handler's Clothing.	1st Lt T. H. Burkhalter	Jan 57	Continuing

Formal studies of problems associated with missile propellant handlers' uniforms have been completed for the existing standard missile systems. Work on a consulting basis to design technicians is continuing and needs for more work for future missile systems are being considered.

3. Human Engineering Compatibility Studies of QM Equipment Used with Missile Systems.	1st Lt T. H. Burkhalter Capt R. L. Mendenhall Dr. J. M. McGinnis	Jan 57	Continuing

The Redstone, LaCrosse, Nike and Corporal Systems have been studied for possible incompatibilities with the QM-equipped soldier. Studies carried out in conjunction with the winterization tests of the Redstone System revealed a relatively small number of incompatibilities. A report has been prepared.

4. Studies to Resolve Major Functional Incompatibilities between QM Designed Standard Items and Those Designed by Other Technical Services.	J. M. McGinnis	July 58	July 59

Previous studies have revealed those QM items most frequently found to be incompatible with items of other services. Follow-up studies are being planned.

5. Areas of Incompatibility between the Soldier and Experimental Arctic Headwear Systems.	J. M. McGinnis	Jan 57	Continuing

Standard headwear and five 1957 experimental cold weather head and face protection systems were studied under conditions of extreme cold. The advantages and limitations of each system have been reported to responsible design technologists and recommendations made which may assist in the continuing development of such protective systems. Studies of the more advanced prototype systems are anticipated.

6. Operational Analysis of Activities of QM Equipped Soldiers Engaged in Selected Typical Military Tasks.	Capt R. L. Mendenhall	Aug 58	Aug 59

An attempt has been made to determine significant military tasks which may be used as criteria for evaluating soldier performance with QM items of equipment. Work will continue with an effort made to design miniature situations having high face validity.

C. HUMAN ENGINEERING FOR DESIGN AND DEVELOPMENT OF QM ITEMS

1. Determination of Movement and Endurance Functions of the Hands and Fingers.	State U. of Iowa Contract	Nov 55	Aug 58

This research was undertaken to provide data on the effects of fatigue on normal hand functions. Such data are to be used for improving handwear design.

2. Measurement of the Size and Force of Foot Movements with Reference to Fatigue Problems.	State U. of Iowa Contract	Sept 55	Aug 58

A series of tests were developed to provide anthropometric data on the foot and to provide information about the effects of fatigue on the functioning weight and non-weight bearing foot. The data obtained from this initial phase of the contract were used to design experimental footgear which may potentially reduce fatigue and increase foot comfort. This footgear is now being studied and evaluated.

3. The Effects of Distribution of Insulation on the Hand upon Hand Temperature and Hand Performance.	J. L. Kobrick	Jan 58	June 59

A series of studies have been designed to investigate the interrelationships existing between local hand temperature, body temperature and amount and location of insulation placed upon the hand. Information obtained will be used to guide handwear designers in an effort to provide maximum protection with minimum interference with hand performance.

Studies	Experimenters	Date Started	Date Completed
4. Protective and Performance Characteristics of Experimental Handwear Varying in Finger Design.	E. R. Dusek	Jan 57	Dec 58

Both the protection afforded by and the performance possible with experimental handwear varying in number of fingers available for manipulation have been evaluated. Preliminary results indicate that protection is critical for the fourth and fifth digits and that performance is not greatly enhanced when these fingers are separated through glove design.

5. Manual Performance While Wearing Experimental "Chinese Sleeve" Handwear.	E. R. Dusek J. L. Kobrick	Sept 57	Sept 58

Several types of handwear worn with the "Chinese Sleeve" have been evaluated with respect to the efficiency of manual performance possible when wearing such handwear. Information obtained is being forwarded to responsible handwear designers.

6. Preparation of a Human Engineering Handbook to Provide Data on the Size and Shape of the Head, Neck and Shoulder Area of the Soldier When Wearing QM Headwear Items.	J. L. Kobrick	Jan 58	June 59

This study will provide information for use by engineers and equipment designers to reduce incompatibilities among related QM items and those of the other Technical Services.

D. ANTHROPOMETRIC CHARACTERISTICS OF THE MILITARY POPULATION FOR HUMAN ENGINEERING OF QMC ITEMS

1. Photometric Analyses of Contour Relief of the Head, Hands and Feet.	R. M. White R. W. Newman	Aug 57	Continuing

Purpose is to collect and describe anthropometric dimensions of a reference population obtained by two photographic contourometers especially developed for this purpose. Both vertical and horizontal contour reliefs with intervals of one-quarter inch or greater can be used. Reference design data for headwear, handwear, and footgear will be obtained.

2. Anthropometric Sizing Studies of Experimental Items of Clothing and Personal Equipment.	R. M. White R. W. Newman	1948	Continuing

Anthropometric sizing studies to determine adequacy of fit, coverage of population, compatibility, etc. are conducted on all new or modified items. Results are published as research study reports with local and special distribution.

3. Small Unit Clothing Tariffs.	R. W. Newman	Jul 57	Continuing

A methodological system for predicting size garment tariffs for small units (1000 men or less) has been established. See report QMC presentation of this conference.

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ARMY CHEMICAL CENTER, MARYLAND

I. Vitae

II. Current Projects

III. Bibliography

RESUME

I. VITAE

Davy, Dr. Earl, Chief, Psychology and Human Engineering Branch.
Ph.D. Columbia University, 1952. Area of Specialization: Physiological Psychology.

Kolovos, Dr. Ernest R., Physiologist, Captain, MSC.
Ph.D. University of Pittsburgh, 1952. Area of Specialization: Physiological Psychology.

Wilber, Dr. Charles G., Chief, Comparative Physiology Branch.
Ph.D. Johns Hopkins University, 1942. Area of Specialization: Environmental and Comparative Physiology.

Woodward, Dr. Arthur A., Jr., Physiologist, Applied Physiology Branch.
Ph.D. University of Pennsylvania, 1947. Area of Specialization: Environmental Physiology.

Grosser, Dr. George S., Psychologist, Psychology and Human Engineering Branch.
Ph.D. Boston University, 1952. Area of Specialization: Physiological Psychology.

Kays, John M., 1st Lieutenant, CmlC, Psychologist.
B.A. Emory University, 1956. Area of Specialization: Experimental Psychology.

Roberts, Albert P., SP3, Social Sciences Assistant.
B.A. Queens College, 1953. Area of Specialization: Experimental Psychology.

Blanton, James E., SP3, Social Sciences Assistant.
B.A. University of Maryland, 1956. Area of Specialization: Psychology.

Shelley, Leon B., Pfc, Mathematical and Statistical Assistant.
B.S. Central Michigan College, 1956. Area of Specialization: Mathematics and Industrial Arts.

Garrett, Ronald S., Pfc, Social Sciences Assistant.
B.A. Louisiana State University, 1956. Area of Specialization: Experimental Psychology.

II. CURRENT PROJECTS

A. Directorate of Medical Research

1. Continuation of the investigation of the effects of GB in sublethal concentrations on human behavior. — June 1957-June 1958

The effect of sub-lethal concentrations of GB on humans was experimentally investigated following whole-body exposure of human subjects to GB at a concentration of 2 mg/m^3 for 2 minutes. Subjects were exposed to GB, and post-exposure performance on battery of tests was compared with performance during the final pre-exposure session. The battery of tests, related to steadiness, dexterity, addition ability, reaction time and eye-hand coordination, was administered during three pre-exposure and three post-exposure sessions. The performance measures were not severely impaired by GB exposure at the Ct employed. Improved performance was noted in many tests. While hand steadiness may be slightly impaired in proportion to the cholinesterase activity decrement, the extent of cholinesterase inhibition was found to be unrelated to the extent of either an impairment or an improvement of performance on the other tests.

2. Evaluation of three experimental model mask-to-mask resuscitators — August 1957-August 1958

The Mask-to-Mask was developed primarily to resuscitate nerve gas casualties. Subjects were enlisted Army and Air Force personnel with no prior experience using resuscitating equipment. Evaluations considered the operating characteristics and functions of the resuscitators from the standpoint of the user. Critical items in the carrier were positioned in easily accessible locations, and an adequate method for packing each experimented model was worked out. A minimum of instruction appeared necessary to train operators to use the resuscitator. Emphasis must be placed, however, on efficient breathing procedures while carrying and breathing a casualty. With the employment of proper breathing, subjects stated it was slightly

more difficult to breathe a casualty than to breathe through the regulation gas mask. The limiting factor in a one-half mile litter carry while breathing a 150-pound simulated bronchioconstricted casualty was fatigue of hand and arm muscles rather than respiratory fatigue.

Tests have shown that the R-1 and R-2 models of the mask-to-mask resuscitator function satisfactorily at -30°F. A trial of the later R-3 model at -30°F. indicates that this model is also functional at low temperatures. Low temperature behavior of all three models is expected to be similar since all have fundamentally identical valve mechanisms. Tests of the model R-2 resuscitator, in which the subjects breathed against resistances up to 40 mm. of Hg, show that outward leaks from the operator's facepiece are neither frequent nor of large magnitude provided that the face piece is well fitted. Proper fitting demands the use of a small size facepiece for persons with narrow or small heads. Tests are in progress on model R-3 to determine the amount of outward and inward leakage at the operator's facepiece.

3. Mask, Protective, Field, E13R9, and M9A1.

A physiological evaluation of the Mask, Protective, Field, E13R9 was made in comparison with M9A1 mask. Endurance tests were conducted under conditions of heavy work, carrying a 49 lb. pack up a 12% grade at 3 miles per hour in 5 different environments. The average endurance times (minutes) showed little difference between the E13 and the M9 masks according to the following data:

	Cold Wet	Cold Dry	Hot Dry	Hot Wet	Temperate
M9	17.9	14.7	4.3	5.5	11.3
E13	13.6	14.5	6.3	5.5	12.8

Speed running tests, indicative of performance in tasks such as a rapid assault maneuver, were carried out with paratroopers wearing the M9A1 and E13R9 gas masks over a 1/2 mile course. These men also ran without masks and with M9 and E13 gas masks with the filtering material removed and therefore with little inspiratory resistance. The average time for running the course with no mask was 174 ± 6 seconds. The masks contributed an increase in running time as follows: M9, 10.9%; E13, 6.9%; M9 without filter, 5.7%. These results were statistically significant at the 95% level. The E13 without filter did not produce a significant increase in running time. The foregoing applies to the entire group of men. In a selected group of well trained men, the effect of the E13 in increasing the running time was not significant. The E13 produces a 7.4% decrease in running time compared to the M9 in well trained men. In men not in top physical condition or poorly motivated the difference between E13 and M9 may not be significant. The E13 mask does not show any significant difference in running time compared to the E13 mask with the filtering material removed. The various mask conditions do not influence final heart rates.

4. Tests are underway on the habitability in summer weather of the Conversion Kit, Medium GP Tent, Protective Shelter, E21. The temperature, humidity, carbon dioxide content and oxygen content of the air in the tent and the heart rate and oral temperature of the human occupants are being measured on a series of representative summer days at Army Chemical Center, Maryland. Indications are that the filter material allows for adequate exchange of respiratory gases, but not for elimination of water vapor under conditions requiring evaporative cooling of the body.

5. The effect of several psychopharmacological agents upon escape behavior, motivation and avoidance behavior. The objective is to assess the effect of various drugs on the efficiency of the escape reactions of organisms to noxious stimulation. Volunteer subjects are required to escape electric shock by maintaining a minimal proficiency of performance on the pursuit rotor. A parallel experiment, using dogs as subjects, requires the organism to remove shock by means of an operant response. The effects of drugs on the frequency of escape responses, the frequency of non-escape ("wasted") responses, and the duration of shock undergone by the organism will be measured in both experiments. Another behavior category under investigation is motivation. Hungry cats are required to traverse an alley to obtain food reinforcement. After the behavior reaches a stable level, the cat is drugged and the effect of the drug on starting latency and running time is determined. The avoidance behavior of cats will be studied, using conditioned negative reinforcers as cues in a T-maze. The effect of drugs on the frequency of correct responses will be determined.

6. Among current investigations a major project has the purpose of predicting the effects of incapacitating agents upon the operation of complex military equipment. Toward this purpose a series of laboratory tests are being selected, both from among existing standardized tests and from measurement techniques now being developed at the Army Chemical Center.

A second approach involves field tests during which standard and candidate chemical agents are administered to persons actually using operational equipment or, in some instances, corresponding simulators. We are especially interested in the effects of these agents upon command and decision functions and upon communications among persons engaged in the operation of fire control systems.

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2. Woodward, A. A. and E. Davy. Effects of Chemical Corps Protective Equipment on the Performance of Engineer Corps Tasks. Chemical Warfare Laboratories Technical Memorandum No. 23-4. August 1957.

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U. S. ARMY SIGNAL RESEARCH AND DEVELOPMENT LABORATORY
FORT MONMOUTH, NEW JERSEY

I. Vitae

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III. Completed Projects

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Huebner, Daniel L., Engineering Psychologist
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II. CURRENT PROJECTS

1. In Service. The Human Factors Engineering Program within USASRDL continues the training, Product Review, consultation and contract surveillance activities, all of which have been described in past conference reports. The results are becoming evident in new equipments which appear to be well designed from the human factors standpoint.

2. Contracts.

Contract No.	Contractor	Duration
DA-36-039 sc-52648	New York University College of Engineering	1 July 57 - 1 Nov 58

Task assignment type contract for performance of human engineering and psychological studies concerning the design of systems being developed for antiaircraft defense. Task assignments classified.

DA-36-039 sc-73253	Dunlap and Associates, Inc.	1 Aug 57 - 31 Jul 59

Studies under way on this task-assignment type contract are:

- Human Engineering Review of Radar Set AN/TPS-25(XE-1)
- Evaluation Procedures for Ground Surveillance Radar Systems
- Standardization of Control Coding for Equipment Families
- Study of the Design of Correction Tables for Flash Ranging Set AN/TVS-1(XE-1)
- Human Factors Engineering Design of Airborne Countermeasures Set AN/ALT-1[illegible] (XE-1)
- Human Factors Engineering Study of Radar Remote Control System AN/UPW-1
- Study of the Speed and Accuracy Penalties of Multi-Scale Meters
- Human Factors Engineering Evaluation of Air-Ground Data Links for Army Aircraft

DA-36-039 sc-75054	American Institute for Research	1 May 58 - 30 Apr 59

Human Engineering Design Recommendations for Miniaturized Equipment. Drastic miniaturization of Signal Corps equipment is creating problems in handling, identification, maintenance and operation because of the obvious lack of concurrent reduction in the size of the users. This study is to point out the limitations of size reduction imposed by the operator's and maintenance man's characteristics, and establish possible solutions of the design problems encountered.

III. COMPLETED PROJECTS

See Bibliography

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